PRODUCT ENGINEERING

JANUARY, 1949

OLDSMOBILE'S 1949 V-8 ENGINE

IN THIS ISSUE — The First "Kettering Type Engine" + Bolt Tightening + Laminated Plastic Bearings + Speed Control for Electrical Drives + Dust Excluder Boots

A McGRAW-HILL PUBLICATION

SPECIFY THE ADDITION OF

NISILOY*

Chilling and consequent machining difficulties were encountered by a foundry specializing in cast parts like these, designed with both heavy and light sections. Nisiloy, added to the ladle, assured ready machinability after many other experiments failed.

for Better Machinability in GRAY IRON CASTINGS

Casting users profit from use of Nisiloy . . . a new, powerful, positive inoculant that promotes better machinability. It contains about 60 per cent nickel, 30 per cent silicon, balance essentially iron.

Faster, easier, lower-cost finishing of gray iron castings may be attained because Nisiloy serves to eliminate localized hard areas or chilled (white) edges and surfaces . . . regardless of sharp variations in section thickness.

EMBLEM OF INCO SERVICE
TRADE MARK

Get full information. Send for *your* free copy of a booklet that describes how the dense, gray, machinable structure secured with Nisiloy reduces machining time, tool wear, rejects and costs. Mail the coupon now.

*Trade mark of The International Nickel Company, Inc.

The International Nickel Company, Inc.
Dept. P. E. 67 Wall Street, New York 5, N. Y.
Please send me your booklet entitled
"NISILOY" for GRAY IRON CASTINGS.

Name..... Title.....
Company.....
Address.....
City..... State.....

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

VOLUME 20

PRODUCT ENGINEERING

NUMBER 1

G. F. NORDENHOLT, *Editor*

Assistant to the Editor, Joseph Kerr • *Managing Editor,* James R. Bright • *Associate Editors,* Harold Schor, V. H. Laughner • *Assistant Editors,* E. S. Cobb, J. D. Cooney, R. Campbell, N. J. Van Ness

Consulting Editor, Robert E. Bruckner • *Washington,* George E. Doying, Jr.

Publisher, Albert Hauptli • *Assistant Publisher,* W. E. Kennedy

Foreign News Bureau: London • Paris • Frankfurt • Moscow • Tokyo • Bombay • Melbourne • Rio de Janeiro • Buenos Aires.

JANUARY 1949

Meeting the Engineering Impasse 81
How to form a new approach to baffling design problems.

Surface Hardened Stainless Steel by Vincent T. Malcolm 84
Properties and characteristics of stainless steels casehardened by the Malcomizing process.

Product Designs 88
1949 Oldsmobile V-8 engine, Cavity resonance measures volume, Press ram actuates hydraulic feeder.

Tightening Characteristics of Nut and Stud Assemblies by William F. Pickel 98
Control of conditions that insure safe, consistent loading of threaded fasteners.

Tensile Tester for Metals at Sub-Zero Temperatures by E. J. Ripling and G. Tuer 103
A method for accurate tensile testing of metals at extremely low temperatures.

Protecting Machine Parts with Dust Excluder Boots by Watson G. Harding 106
Composition, design and application of five types of reinforced synthetic rubber boots.

Laminated Plastic Bearings by E. P. Littlefield 111
Advantages and limitations of laminated plastics in heavy duty and severe service bearings.

Bonded Resistance Wire Gages for Strain Measurements by Arthur C. Ruge 116
Illustrates ten types of gages and outlines the factors involved in their proper selection.

Involute Curve Layouts by Michael Vasvari 128
Method of calculating coordinates of points on the involute of a circle.

Speed Control for Electrical Drives by R. B. Immel 129
Performance characteristics, circuits, and equipment data needed to select the proper control.

Belleville Spring Design Charts by Leslie W. Jones 161
Charts for springs having zero, ten, and twenty percent rate pressure rise.

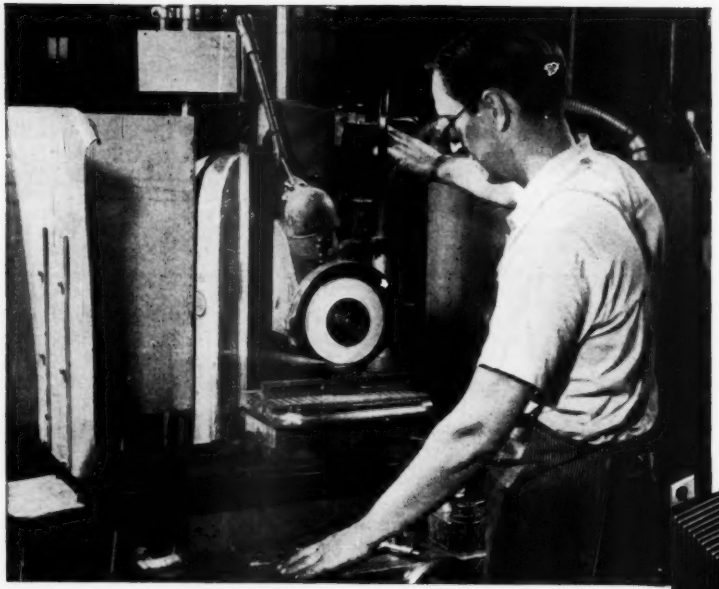
FRONT COVER—1949 Oldsmobile V-8 engine, with engineering personnel (left to right) L. A. Kintigh, experimental engineer; Gilbert Burrell, motor engineer; H. N. Metzel, assistant chief engineer; J. F. Wolfram, chief engineer. Kodachrome courtesy of Oldsmobile Division of General Motors.

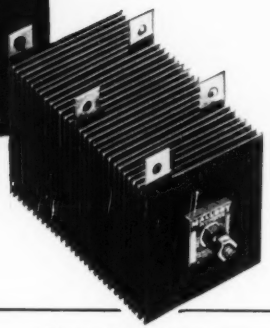
DEPARTMENTS

Highlights 3
Editorial 79
Engineering Abstracts ... 118
Technical News 122
Washington Notes 125
New Materials and Parts. 169
New Books 182
Our Readers Say 192

Publication Office: 99-129 North Broadway, Albany 1, N. Y. Return postage guaranteed. **Published Monthly** by McGraw-Hill Publishing Company, Inc., James H. McGraw 1860-1948, Founder: James H. McGraw, Jr., President; Curtis W. McGraw, Vice-President and Treasurer; Eugene Duffield, Executive Assistant for Publications; Nelson Bond, Director of Advertising; Joseph A. Gerardi, Secretary; J. E. Blackburn Jr., Director of Circulation.
Correspondence About Subscriptions should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.
Subscription Rates: Single copies 75c, United States and possessions, $6 for one year, $9 or two years, $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $16 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.
Editorial and Executive Offices: 330 W. 42nd St., New York 18, N. Y. Cable address: "McGraw-Hill, New York."
Branch Offices: ATLANTA, R. M. Maultsby, 1011 Rhodes-Haverty Bldg.; BOSTON, John H. Koch, M. A. Williamson, Jr., 1427 Statler Bldg.; CHICAGO, Ray Dreh, Anson E. Meanor, 520 N. Michigan Ave.; CINCINNATI, R. H. Anderson, 1110 Delta Ave.; CLEVELAND, A. F. Tischer and R. H. Anderson, 1510 Hanna Bldg.; DETROIT, G. P. Weatherby, 2089 Penobscot Bldg.; LOS ANGELES, C. W. Dysinger, 622 S. Hope St.; NEW YORK, J. A. McGraw, Hugh Britton, 330 W. 42nd St.; PHILADELPHIA, David G. Jones, Architects Bldg., 17th and Sansom Sts.; PITTSBURGH, 738-9 Oliver Bldg.; ST. LOUIS, Continental Bldg.; SAN FRANCISCO, J. W. Otterson, 68 Post St.; WASHINGTON, National Press Bldg.; LONDON, Aldwych House, Aldwych, W. C. 2, England.

Entered as second-class matter Aug. 21, 1936, at Post Office, Albany, N. Y., under act of Mar. 3, 1879. Printed in U.S.A. Members of A.B.P., A.B.C. Copyright 1949 by McGraw-Hill Publishing Co., Inc. All rights reserved.





"...Worked So Well We've Forgotten About It!"

That's the kind of report we like to hear—because it describes a Mallory Magnesium-Copper Sulfide Rectifier Stack which has served *ten years—in daily operation—with minimum maintenance.* Its job—supplying DC current for the operation of a magnetic chuck on each of five surface grinders such as the one shown above. Its performance—it still gives over 90% of its original efficiency.

This is not surprising. Mallory Magnesium-Copper Sulfide Rectifier Stacks are made rugged—practically immune to damage or abuse. Rectification is confined to core of the stack—the outside fins are for heat dissipation only. No liquids, bulbs or moving parts—nothing to give trouble or wear out. And Mallory Mg-CuS rectifier stacks are more than "the world's toughest rectifiers"—when subjected to abnormal voltage surges, their rectifying junctions are so made that they actually heal themselves.

No wonder millions are in use. Write for more information or for engineering help.

Check These Features:

- √ **Proved long life**
- √ **Unaffected by high temperatures**
- √ **Withstands abuse and accidental short circuits**
- √ **Self-healing rectifying junctions**
- √ **Constant output over many years**
- √ **Resists harmful atmospheric conditions**
- √ **Rugged, all-metal construction**
- √ **No bulbs, no brushes, no sparking contacts**

Mg-CuS Rectifier Stacks and Power Supplies

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors — Rectifiers
Contacts — Switches
Controls — Vibrators
Power Supplies
Resistance Welding Materials

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

LIQUID STAINLESS STEEL, a mixture of pure 18-8 stainless in microscopic flake form with vinyl resins and a volatile thinner, is an effective protective and decorative coating for wood, metal, absorbent surfaces and other finishing materials. Principle properties include high resistance to corrosion, chemical agents and abrasion, as well as good light and heat stability. Aniline dyes can be added to the bluish gray base mixture.

SILVER-TITANIUM solder is being used to seal the metal base to the ceramic parts of ultra-high frequency electron tubes. Alloy can also be used for ceramic-to-ceramic seals.

THE B-36 BOMBER contains approximately 8,000 lb of magnesium -- about 10 percent of the total weight. Some of the more important uses include the skin on about half of the fuselage, leading edges of wings and control surfaces, inner and outer skins for the de-icing system, and the majority of the castings used in the air frame. Use of magnesium has saved 1,900 lb which increases the cruising range by 190 miles.

STEEL EXPORTS during first half of 1948 were 26 percent lower than for same period during the previous year. Rapidly expanding production in ERP countries accounts largely for this drop.

SHOT GUN BARRELS and breech mechanisms made of duralumin serve equally as well as the steel type. The alloy provides improved damping capacity and reduces vibration. New gun weighs 4 lb, 5 ounces.

MUFFLERS coated on the inside with aluminum last 20 times as long as the conventional steel assemblies used on autos.

NICKEL-FACED electroplates have proven most satisfactory for printing on cardboard and similar materials. Copper plates wear out after 400,000 impressions while nickel plates are good for over 900,000 operations.

POROUS CHROMIUM PLATING on the cylinder walls of small gasoline engines using aluminum cylinders and pistons has obviated the use of steel liners. Heat transfer characteristics are improved permitting a step up of the compression ratio from 5:1 to 6:1, and the virtual elimination of hot spots.

AN ALL-ALUMINUM BRIDGE 504 ft between abutments is under construction in Quebec, Canada. Structure will weigh 2,000 tons less than a similar bridge made of steel; some bridges already in use are part aluminum.

NONMETALLIC MATERIALS

ELECTRICALLY CONDUCTIVE PLASTIC becomes a heating element after spray application and curing. Material, called Electrofilm, is already in use as a thermal de-icing medium in aircraft cabin air combustion heater intakes. Element receives 250 w from 27 v circuit and maintains 100 F intake temperature with 30 F outside air.

GAS GUARD, a new anti-freeze solution, absorbs moisture in gasoline and prevents ice from forming in automotive fuel lines. As much as 10 oz of water in 15 gal of gas maintained at — 30 F can be assimilated. There is no detrimental effect on fuel or engine.

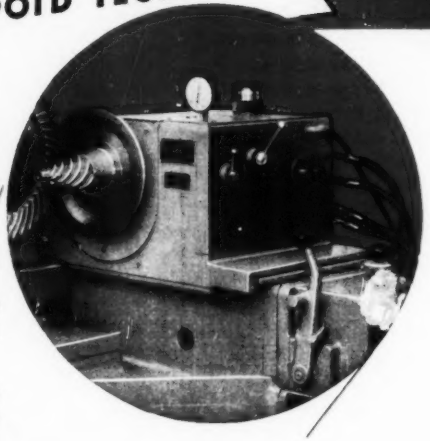
BAGASSE, the fibrous residue of sugar cane refining is combined via heat and pressure with phenolic resin binder to form pressed board for structural uses.

Continued on Page 5

SIMPLIFIED TESTING

WITH THE NEW GLEASON NO. 17A HYPOID TESTER

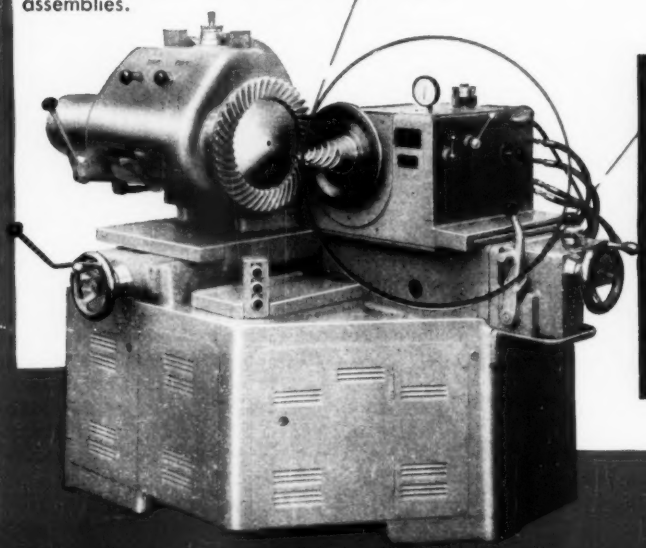
A running test, simulating actual operation of gears in final assembly, is the only positive method of determining how gears will operate in their final mountings.



BEFORE PRODUCTION—to establish the correct setup for the gear cutting machine.

DURING PRODUCTION—to maintain uniform quality of the cut gears.

FINAL TEST—to find the best running quality of the gears for assembly . . . eliminating costly fitting or tearing down and rebuilding of assemblies.



Correct mounting may now be read simply and easily from an indicator with the New Gleason No. 17A Tester. Designed with a dial adjustment which once set up, automatically duplicates backlash on each pair of gears, this machine simplifies obtaining the best running position of gears in final assembly.

GLEASON *Works*
1000 University Avenue
Rochester 3, N. Y., U. S. A.

Builders of Bevel Gear Machinery for Over Eighty Years

DRY-TYPE LUBRICANT composed of molybdenum-disulphide powder resists bearing pressures of more than 100,000 psi. Material, trade-named Molykote, has low coefficient of friction and functions equally well at high or low sliding velocities.

LIQUID MASKING TAPE based on vinyl resins saves time and effort by keeping paints and lacquers off wood, glass and metallic surfaces. After brush application, solution dries in 10 sec. The shield is easily peeled off when surface is dry.

A TREND in the plastics field may be indicated by Celanese' decision to discontinue production of all cellulose nitrate products. Future activities will be concentrated on cellulose acetate and other new materials.

ELECTRICAL INSULATING TAPE is self-bonding and will cohere to butyl rubber, polyethylene and vinyl resins. Known as Bi-Seal, the resinous synthetic has a dielectric strength of 1,000 v per mil and is resistant to moisture and acids.

REFLECTIVE SHEETING of the "Scotchlite" type serves as a safety improvement for cars. Available in all colors, finishing material grips on contact to form smooth glossy surface. Daytime appearance is unchanged but, at night, light reflects shape and color of the car.

MOLDED SILICONE RESINS are being combined with most types of fiber and fabrics such as cotton, nylon, glass and asbestos. Results are improved heat and electrical resistance, better impact strength.

A VERSATILE LATEX compound withstands temperatures up to 400 F, has a tensile strength of 2,500 psi, elongates up to 1,000 percent and resists most chemical agents. Trade name is Anodex HR.

SPECIAL SYNTHETIC RUBBER remains flexible at temperatures down to -50 F. Specific gravity is 1.25 and durometer hardness is 55. Butaprene-based compound can be extruded, lathe-cut, molded or punched.

ORLON, Du Pont's new synthetic fiber, known until recently as experimental "Fiber A", will be produced commercially. New all-synthetic fiber has the strength of nylon and effectively resists sunlight and mineral acids, as well as attacks by insects and fungi.

PARTS WEAR in diesel engines is being reduced as much as nine-tenths by Shell Oil's new Rimula lubricant. Heavy-duty compound was developed for use in power plants burning low cetane fuels having a high sulphur content. Applicable also where jacket temperatures run below 140 F.

ANTI-KNOCK QUALITY of existing automotive fuels can be raised 10 to 20 numbers, it is reported, by a liquid coolant injected from an accessory called Vitameter. Fluid consists of 85 percent alcohol, 15 percent water, some tetraethyl lead and a corrosion inhibitor. Invention may serve as carry-over medium until oil companies can produce large supplies of 90-95 octane fuel for new high-compression engines.

PROCESSES

A PROCESS that is expected to compete in costs with the tanbark method for making shoe uppers and soles involves introducing two plastics, carbamide and formaldehyde, into the hide after it is treated with glyoxal, a semi-oxidized alcohol derivative.

BRITAIN'S "centri-die" casting process which produces superhard alloys to withstand the intense heat generated in a jet engine, has been released to an American steel foundry. Process utilizes newest techniques of permanent mold, centrifugal casting.

PLASTIC FILMS can be made porous so that they breathe like fabrics and leather by the Electro-Vent process. A stream of electric sparks burns minute holes, 64 to the square inch, permitting passage of air without allowing water to penetrate.

CAVITIES common to steel ingots are being eliminated by a processing step called

Continued on Page 7

Rivnuts solve tough problem in NEW BUILDING DESIGN

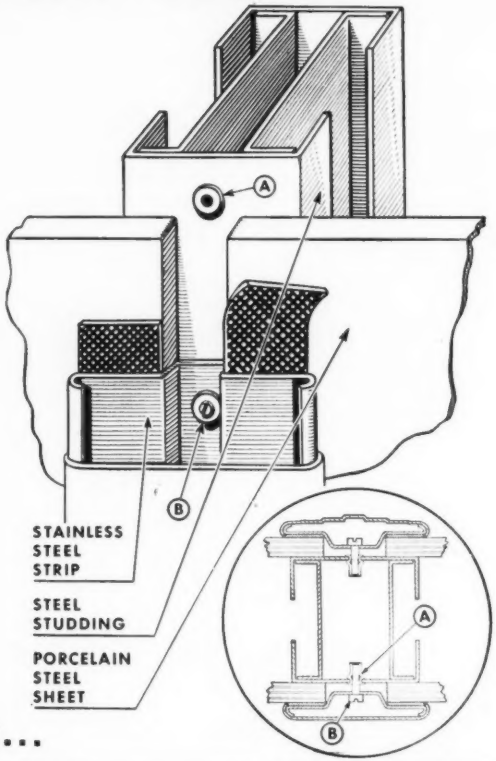
Architects for a "quick-lunch" restaurant chain had an exceptionally tough problem in designing their new pre-fabricated building. Walls of porcelain steel had to be attached to the steel upright studding in such a way that they could be easily torn down and moved. Good sealing was a must. Because B. F. Goodrich Rivnuts serve as both blind rivets and nut plates, they provided the ideal solution.

FLAT HEAD RIVNUT

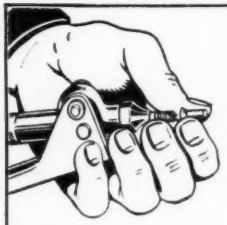
Rivnut "A" is inserted in the studding and upset. Its flat head and the firm bulge formed in its shank grip the studding tightly. The still-intact Rivnut threads furnish a deep nut plate for attaching the walls.

When threaded into the Rivnut, cap screw "B" securely fastens the steel strip (which holds the porcelain sheets and asphalt sealing) to the studding. A trim strip is snapped into place to complete the outside assembly. Interior panels are similarly attached.

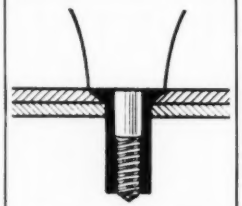
Because these walls can be removed quickly and easily for either moving or repair, Rivnuts mean big dividends in time and money saved. If *you* have a fastening problem, why not consult a Rivnut engineer? Write to The B. F. Goodrich Company, Dept. PE-19, Akron, Ohio.



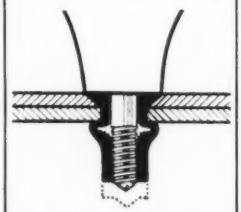
. . . installation is simple and quick . . .



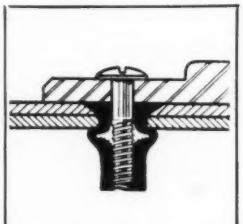
1. Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2. Rivnut is inserted —with head firmly against, and at right angles to, work.



3. Tool lever operates to retract pull-up stud, forming a bulge in the Rivnut shank.



4. After upset, Rivnut threads are still clean and intact, ready for screw attachment.

GET YOUR FREE COPY OF RIVNUT DATA BOOK

Latest edition, fully illustrated. Tells how to use Rivnuts. Gives types, sizes, load capacities. Describes new heading tools. For your free copy, write to The B. F. Goodrich Company, Dept. PE-19, Akron, Ohio.

B.F.Goodrich

RIVNUTS

It's a rivet—It's a nutplate

Electric Hot Topping. Electric heating of a flux and molten metal maintained on the ingot protects the steel during the solidification period.

A "DRY" PLATING PROCESS permits application of Tn, Ni, Fe, Cr and Mo to any material that will withstand a 400 F temperature. Objects are radiant heated in a chamber containing metal carbonyls. Their decomposition takes place in an inert atmosphere of carbon dioxide.

EQUIPMENT

EVAPORATIVE CONDENSERS use both forced air and a water spray to cool hot refrigerant vapor. As no circulating water system is needed, a saving of 90 percent in water consumption is made.

A 48-OZ INJECTION MACHINE has a clamping pressure in excess of 2-million lb and platens over four feet square. The press is reported to be the largest of this type thus far installed by a custom molder.

STRESSES produced in mechanical parts by electroplated finishes can be evaluated by an instrument called the Spiral Contactometer. Degree of twist of an 18-8 steel spiral strip placed in the plating solution is the indicating element.

PACKAGING MACHINE, probably the world's largest, automatically wraps stacks of a half-dozen sheets of insulating wallboard four feet wide and ten feet long at a rate of two packages per min. With it, two men will do the work that requires 16 by hand methods.

HUGE 2,300-TON MAGNET is the heart of Columbia University's new cyclotron. When completed, machine will be capable of accelerating hydrogen nuclei to a speed two-thirds that of light.

IMPROVED THICKNESS DETECTOR, for non-destructive thickness measurements of plastics, glass and other materials from one side has adjustable frequency modulation to facilitate the measurement of severely corroded equipment, a permeability tuning device for increased sensitivity and increased frequency range for measurement down to 1/16 in. Special ranges can be provided for thinner materials.

A LENS ANALYZER permits study of photographic and television picture detail. Equipment which includes a microscope, television camera, kinescope tube and oscilloscope measures and indicates lens contrast response or power of focus in terms of picture detail lines per millimeter.

"STRIKE ATTACK" CAMERA for recording damage done by fast, low-flying fighters takes 70 mm pictures at rate of five per sec. Shutter speeds of 1/2,500 sec are utilized.

MISCELLANEOUS

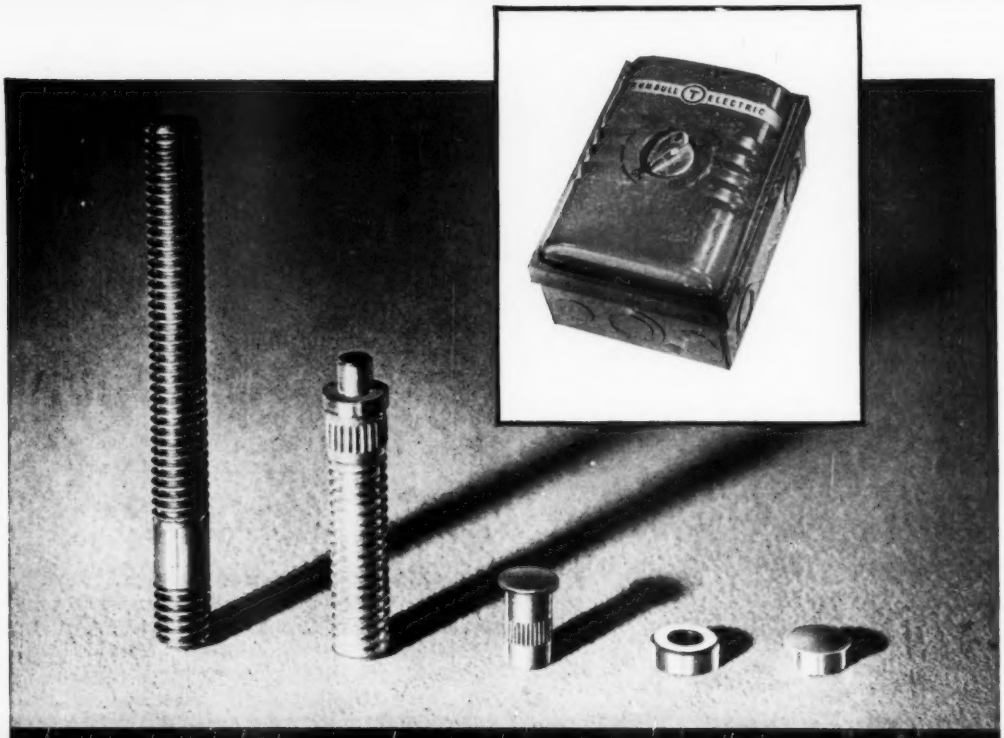
TWO JET BOMBERS are under development in England. Armstrong Whitworth are working on an eight jet flying wing type bomber roughly similar to Northrop's YB-49. Handley-Page have a design for a four jet swept-wing tailless bomber now in the model stage.

TWENTY-SIX GATES, each weighing 35 tons and sheathed in stainless steel, will be built for the new Conemaugh River Dam in western Pennsylvania. Quarter-inch sheathing will be used on all surfaces exposed to the highly acidic water.

AN ELEVATOR SYSTEM for office buildings can be set to six different traffic patterns. Dubbed "autotronic elevatoring", electronic system automatically controls car dispatching and spacing. Passenger waiting time is measured by condensers that charge to a predetermined voltage.

DEEP-DRAWN, ROLLED-THREAD INSERT for use in molded plastics parts costs about half as much as a brass part of the same size. Made of light gage steel, insert is more resilient under pressure than screw machine parts. Thin wall section permits use close to edges and corners of molded parts.

SILICONE RUBBER is now being die-punched into washers, gaskets, seals and packings. Standard and special flat shapes can be held to the tolerances used for the metal and cork counterparts.



A CASE HISTORY SHOWING THAT

REVERE FREE-CUTTING COPPER SAVES MONEY

IF your product requires machined copper parts, it will pay you to investigate savings in machining costs made possible by Revere Free-Cutting Copper Rod. We would suggest that you make trial runs of this metal to prove what it will do under your own shop conditions. That was the procedure followed by The Trumbull Electric Mfg. Co., Plainville, Conn., with these results:

Part #18107 and 18108, contacts for the Type D switch illustrated, were designed around this alloy. Trumbull states: "On both these parts we found we could make them in one operation instead of two. That is, due to the smooth free cutting of the metal, it was unnecessary to perform a facing operation . . . Our screw machine foreman advises that, in his opinion, both these parts could be made four times as fast as out of ordinary electrolytic copper rod."

#3731, 60 amp. post stud.—5,760 pieces run in 19.6 hours with no machine down-time; 10,425 pieces of ordinary copper rod run in 66.6 hours with 11.8 hours machine down-time. In addition to the extra time required, three sets of dies were used for the regular rod. "The savings of the free-cutting material over ordinary copper were figured at $1.81 per thousand, including in these costs both material and direct labor."

#16552, space washer. "Savings per thousand over electrolytic copper were 77¢. This figure included the material difference and direct labor. In addition, there was an 18% saving in machine down-time."

#K-60-1A, 70-200 amp. stud. "The use of Free-Cutting Copper Rod on this part very definitely increased production and practically voided machine down-time."

In a letter to Revere, Trumbull added: "In general, at least for most of the parts we have used, we find that there is at least a 25% saving in machine time of free-cutting over regular copper. In addition, the workers are enthusiastic about this material, particularly when running studs, because of the fact that it is no longer necessary for them to keep a constant close watch on the machine to see that the turnings do not become tangled up with the moving parts of the machine."

The Trumbull experience is being duplicated in other machine shops. If you have not tried this Revere Metal, we suggest you get in touch with your nearest Revere Sales Office.

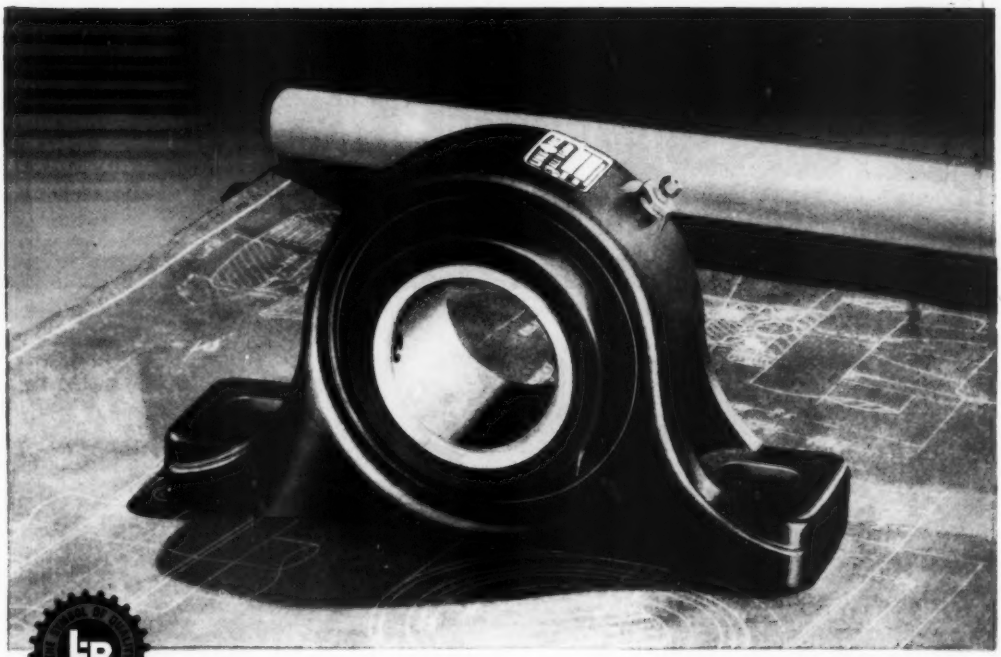
REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y. — Sales Offices in Principal Cities, Distributors Everywhere.



TAKE *QUALITY* FOR GRANTED

SPECIFY *LINK-BELT* BALL AND ROLLER BEARINGS

You can **Depend** upon LINK-BELT for:

1 QUALITY
2 PERFORMANCE
3 ECONOMY
4 ACCEPTANCE
5 COMPLETENESS
6 SERVICE

There's no question about the high quality of Link-Belt Ball and Roller Bearings.

Considering the precision manufacturing processes, the skilled use of the most modern equipment under closest control, and the years of scientific research to furnish industry with longer-lasting, more efficient bearings, it is little wonder that "Link-Belt" quality is unquestioned.

Eliminate all guesswork — specify "Link-Belt" on your next bearing order. Choose with the utmost confidence from the COMPLETE Link-Belt line . . . various mountings and sizes for practically all types of industrial applications.

Good supplies of these popular bearings await your commands at distributor's and Link-Belt stockrooms throughout the nation.

11,827

Free Catalogs On Request!

LINK-BELT COMPANY

Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.

LINK-BELT BALL AND ROLLER BEARINGS

Designer's

ANNOUNCING a complete ALL-NEW line

NEMA sizes 0, 1, 2, 3
for a-c motors up to 50 hp

MOTOR STARTERS

Designed for Easy Maintenance

Built so you can forget them

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON GE PRODUCTS

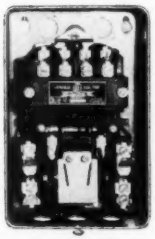
ALL-NEW Magnetic Contactors

Plenty of new features will interest designers in these new G-E a-c contactors, available in NEMA sizes 00, 0, 1, 2 and 3. All terminals are accessible from the front and have large pan-head or slotted hex-head screws to speed wiring. Main poles in sizes 00, 0 and 1—and interlocks in all sizes—can be changed from normally open to normally closed with no extra parts needed. This facilitates last-minute changes and reduces need for stocking "specials." Extra two-circuit interlocks with interchangeable normally open to normally closed contacts can be added to either side of the contactor. Other new features include springs permanently attached to moving contact tips, lock washers fastened to all screws, and long-life magnet with permanent air gap. For easy inspection and maintenance, contacts can be completely exposed for inspection by loosening two screws to remove arc hood, contacts can be replaced without disturbing wiring, and coil is easily replaced by removing four screws which hold magnet in place. See Bulletin GEA-5154.

ALL-NEW 'Strongbox' Magnet Coil

safeguards windings from dust, oil, water

Here's the stout heart of this all-new General Electric line of contactors, starters, and combination starters. Compare it with others and you'll agree the "Strongbox" Magnet Coil is the toughest you've ever seen. For long life even under severe conditions, it's firmly locked in a molded plastic block that completely protects the Formex® windings against dust, oil, and water. A permanent lubricant keeps the moving structure ready for action at all times. Slotted edges in the block keep the magnet travelling in a straight line with minimum wear. Maintenance is quick and easy—permanently anchored terminals won't loosen from the coil, and screwdrivers can't damage windings during wiring.



ALL-NEW Motor Starters

Check these G-E magnetic a-c starters on points that count with machinery manufacturers. Fine silver tips and extra-heavy construction of contacts mean extra long life. Molded, burn-resistant arc hood snuffs arcs at once—prolongs contact life. A flick of the finger changes the overload relays from hand to automatic reset. Available in non-reversing, reversing, and multi-speed types. See Bulletin GEA-5153.

ALL-NEW Combination Starters

A single, compact unit, the new G-E combination magnetic starter saves space and installation time. The rotary-action fused disconnect switch meets all National Electric Code requirements for circuit isolation and short circuit protection. The magnetic starter with its overload relays give the quick response needed to protect your motor from overloads. Units are also available with circuit breakers or non-fusible switches, if desired. See Bulletin GEA-5156.

General Electric Company, Section C668-67
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ GEA-5153—A-c motor starters
- ☐ GEA-5154—A-c contactors
- ☐ GEA-5156—Combination a-c starters

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name .....

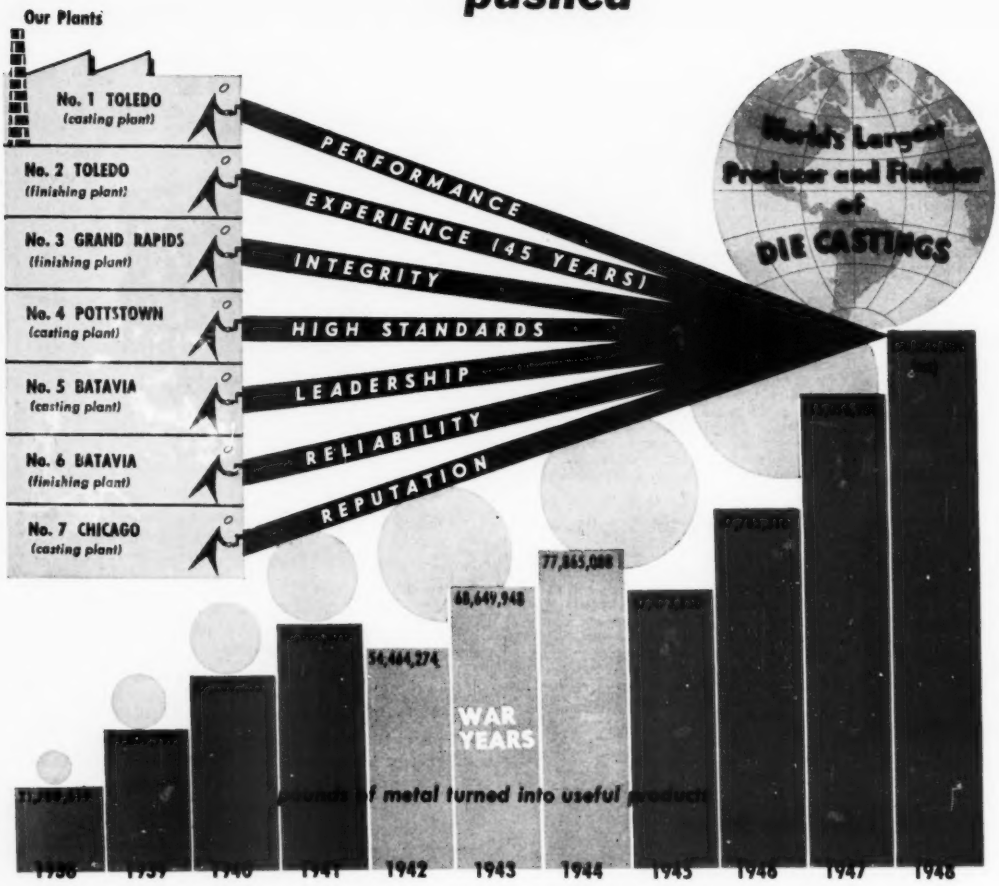
Company .....

Street .....

City ..... State .....

progress doesn't roll uphill

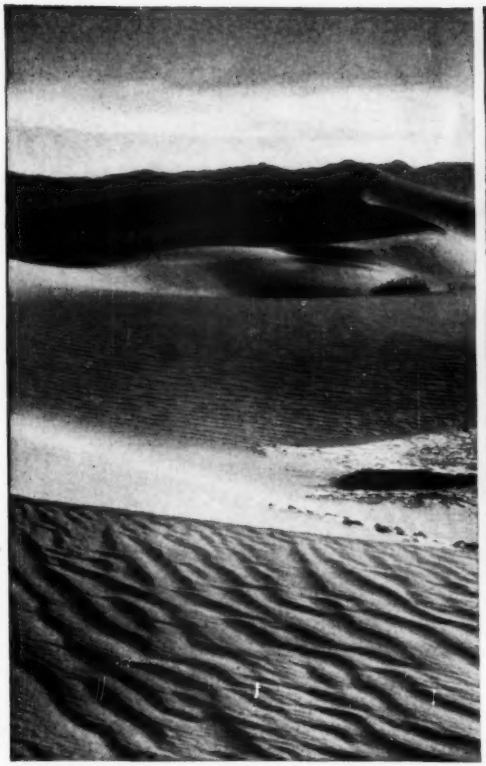
it has to be steadily pushed



DOEHLER-JARVIS CORPORATION

The World's Largest Producer and Finisher of Die Castings

Executive Office
386 FOURTH AVENUE
NEW YORK 16, N. Y.



Death Valley, Calif.

Near Mt. Baker, Wash.

Do you want

RESISTANCE TO EXTREME TEMPERATURES?

Hycar has it - plus

ALL THESE 7 OTHER ADVANTAGES!

1. Abrasion Resistance—50% greater than crude rubber.
2. Extreme Oil Resistance—insuring dimensional stability of parts.
3. Minimum Cold Flow—even at elevated temperatures.
4. Age Resistance—exceptionally resistant to checking or cracking due to oxidation.
5. Hardness Range—compounds can be varied from extremely soft to bone hard.
6. Light Weight—15% to 25% lighter than many other American rubbers.
7. Non-adherent to Metal—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)

For more information, write or ask your supplier to write B. F. Goodrich Chemical Company, Dept. HJ-1, Rose Building, Cleveland 15, Ohio.

Hycar
Reg. U.S. Pat. Off.
American Rubber

B. F. Goodrich Chemical Company

A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

To combat rising costs, alert manufacturers are turning to automatic production control—automatic control of both quantity and quality of machine output.

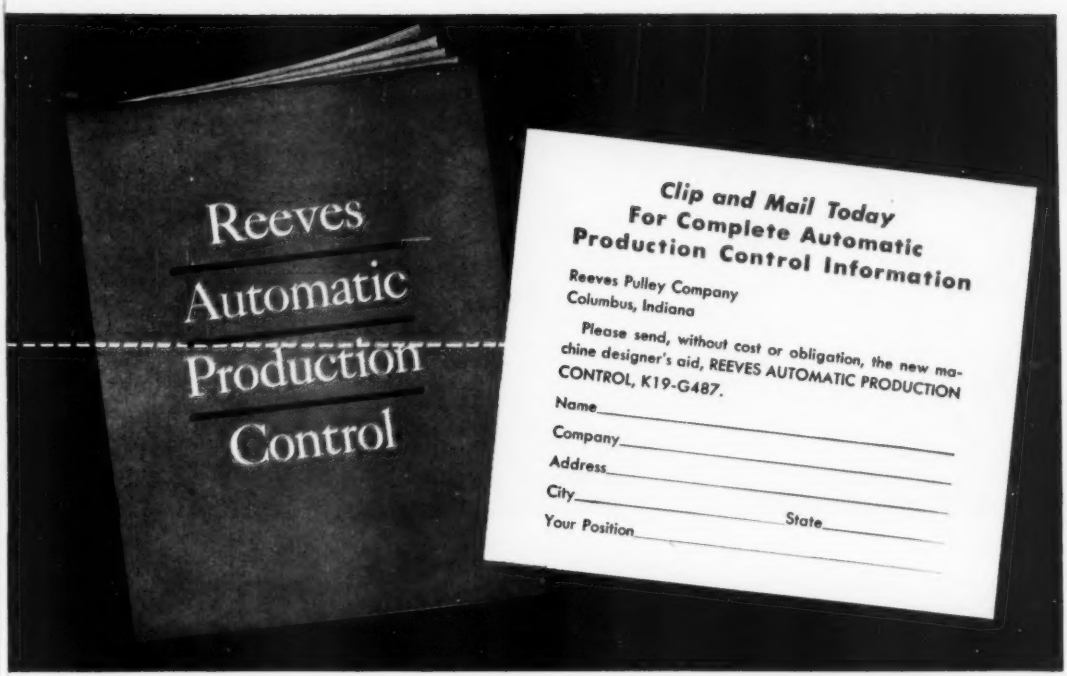
REEVES, again—as in the field of manual speed control—provides tested and proven solutions to the automatic production control problems of machine designers and builders who serve cost-conscious modern industry. These solutions are available in a generously illustrated and diagramed 16-page booklet, REEVES AUTOMATIC PRODUCTION CONTROL. It's yours, for the asking—*without cost or obligation.*

This helpful, new booklet contains the answers to your questions concerning:

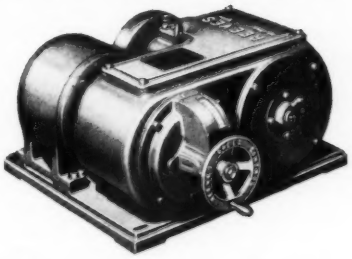
- Hydraulic Automatic Control
- Mechanical Automatic Control
- Differential Automatic Control
- Synchronizing Two or More Machines
- Maintaining Constant Tension
- Maintaining Constant Velocity
- Speed Indicating Mechanisms and Their Applications

If you have a particular problem which is "not in the book," the experienced REEVES Speed Control specialist nearest you will be glad to discuss it with you and make specific, money-saving recommendations. Write for the name of your nearest representative. And, meanwhile, be sure to get the new REEVES booklet . . . merely by clipping and mailing the coupon which appears on the opposite page. . . . Do it today!

REEVES PULLEY COMPANY • COLUMBUS, INDIANA



Here are the REEVES Automatic Production Control Units for application to the machines you build!



The REEVES Vari-Speed Motodrive

The REEVES Vari-Speed Motodrive combines a constant speed driving motor, variable speed control mechanism and speed reducing gears (where required) in one compact, self-contained unit. Designed for use on production machines of all types, it is particularly well adapted to installations where space is limited or where direct connection to the machine is desired. *Efficient Automatic Production Control becomes a reality when this unit is equipped with any one of the three REEVES Automatic Controls.* Motodrive is available in six sizes, in capacities from ¼ to 20 hp. and in speed ratios from 2:1 through 6:1. Helical reduction gears may be incorporated to provide the desired output speeds.

The REEVES Variable Speed Transmission

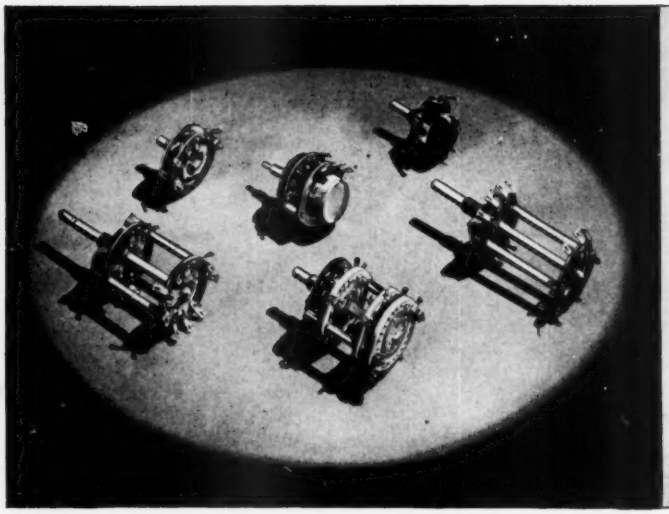
The REEVES Variable Speed Transmission is the original mechanically correct, self-contained unit providing adjustable speed control for industrial machines. It incorporates the proven principle of a V-belt driving between two pairs of adjustable cone-faced discs mounted on parallel shafts. One shaft receives power at constant speed from a motor, line-shaft, etc. The variable speed shaft transmits power to the driven machine, while it is in operation, at infinitely adjustable, stepless speeds above and below speed of constant speed shaft as the V-belt assumes different diameters of contacts against each set of discs. *When used with any of the three REEVES Automatic Controls, the unit becomes a complete system for automatic production control.* Transmission is available in speed ratios from 2:1 through 16:1; in capacities of fractional to 87 hp.

ACCURATE • VARIABLE

Reeves Speed Control

GIVES THE RIGHT SPEED FOR EVERY JOB!

Recognized Leader in the Field of Speed Control Engineering



Use a Switch Worthy of Your Design

There is no substitute for MALLORY Quality Switches *!*

Mallory RS switches are designed to give you everything you want—maximum efficient service, substantial construction, precision manufacture. Mallory switches are constructed with cam and ball type index assembly, or with positive indexing hill-and-valley double roller type index assembly. Note these many features of the Mallory RS series which make their dependability and quality known wherever switches are used. These advantages are of extreme importance in television and high-frequency applications where stability is essential.

- Insulation of high-grade, low-loss laminated phenolic.
- Terminals and contacts of special Mallory spring alloy, heavily silver-plated to insure long life at low contact resistance.
- Terminals held securely by exclusive Mallory two-point fastening—heavy staples prevent loosening or twisting.
- Double wiping action on contacts with an inherent flexing feature—insures good electrical contact with the rotor shoes throughout rotation.
- Six rotor supports on the stator—insure accurate alignment.
- Brass rotor shoes, heavily silver-plated—insure low contact resistance.
- All shoes held flat and securely to phenolic rotor by rivets—prevents stubbing—insures smooth rotation—*minimum of noise in critical circuits.*

The Mallory RS series consists of RS-30, RS-40, RS-50, RSA-50, and RSA-60.

ENGINEERING DATA SHEETS

Send for the Mallory Engineering Data Sheets on the RS series. They contain complete specifications for available circuit combinations with respective terminal locations, dimensional drawings — everything the engineer needs.

SPECIFICATION SHEETS

Specification sheets for all RS switches have also been prepared. These sheets are printed on thin paper to permit blueprinting. The sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to your requirements.

Precision Electronic Parts—Switches, Controls, Resistors

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO. INC. INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors — Rectifiers
Contacts — Switches
Controls — Vibrators
Power Supplies
Resistance Welding Materials

NOW...Only one name you need to know in polystyrene:

Monsanto's Multi-purpose Polystyrene

Monsanto is glad to cooperate in the effort of the plastics industry to simplify trade-names.

As of January 1, 1949, *all Monsanto polystyrene will be known by one name only:* **LUSTREX.**

This decision will simplify materials buying and product promotion . . . from the molder clear through to the ultimate consumer. Now the full force of Monsanto's effective promotion and advertising can be concentrated behind the Lustrex name . . . another obvious advantage for all molders and manufacturers who tie in with the Lustrex labeling program.

Lustrex: Reg. U. S. Pat. Off.

Lustrex special formula modifications (including a number of new ones) to suit particular applications will be designated by suitable suffixes as shown in the table at right. This will make for convenience in ordering, but no attempt will be made to carry these symbols beyond the trade.

LUSTREX	
LUSTREX L	
LUSTREX LX	
Special formulations for specific uses	
LUSTREX L-P1L	General purpose polystyrene.
LUSTREX L-P1	Transparent colors and crystal with superior clarity.
LUSTREX L-P1X	Improved moldability over L-P1; available in crystal only.
LUSTREX L-P1A	Improved moldability in transparent colors.
LUSTREX L-P1D	Translucent and opaque colors with exceptionally good moldability.
LUSTREX LX-P1L	All the excellent properties of L-P1L plus highest heat resistance of any commercially available polystyrene.

For full information about Monsanto polystyrenes and Monsanto merchandising assistance to molders, use the handy coupon.

MONSANTO CHEMICAL COMPANY, PLASTICS DIV.
Dept. PEP 15 Springfield 2, Mass.

Please send me complete technical data on Lustrex polystyrene ☐; on Monsanto merchandising ☐.

Name _____ Title _____

Company _____

Address _____

City _____ State _____

SERVING INDUSTRY . . . WHICH SERVES MANKIND

ELECTRUNITE STAINLESS STEEL TUBING IS

Uniform Throughout

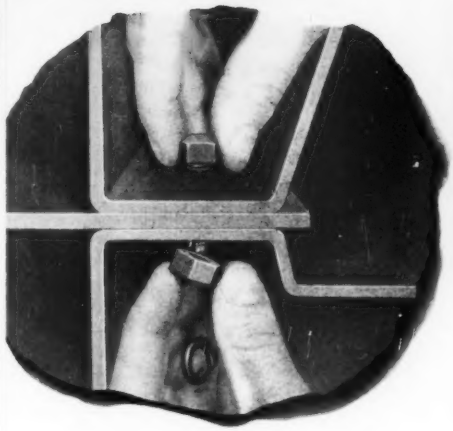
● Throughout every length and every shipment you can depend upon consistent uniformity in ELECTRUNITE Stainless Steel Tubing.

As made by Republic's modern processes of cold-forming and electric welding, each length of ELECTRUNITE Tubing is uniform in wall thickness, diameter, concentricity and high ductility. Close visual inspection of the flat-rolled steel before it is formed into tubular shape, gives positive assurance that the inner surface of every tube is free from any trouble-inviting defects.

ELECTRUNITE Stainless Steel Tubing is available for PROMPT delivery in a wide range of analyses and gauges —in both tubing and pipe sizes. For complete information, write us *today*.

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Dept.: Chrysler Bldg., New York 17, N.Y.

Republic REPUBLIC STEEL
ELECTRUNITE
STAINLESS STEEL TUBING



Eliminate *Practices*

from your assembly line fastening picture with EATON SPRINGTITES and SEMS

Eaton Springtites are quality Reliance Spring Lock Washers of correct type and size pre-assembled on quality bolts and screws so they *can't come off*. The shank diameter fit of the Reliance Spring Washer on screws or bolts is so designed as to give the spring lock washer freedom of movement to rotate and act as a hardened thrust bearing, allowing greater torque in tightening the screws and bolts in the assembly.

Eaton Springtites eliminate assembling of lock washers on screws or bolts before they can be used—*save time and money*.

Eaton Springtites eliminate the chance of a bolt or screw being used in an assembly without a spring lock washer or with the wrong type or size spring washer—*protect your product and its performance*.

Eaton Springtites save time and space in the store room; simplify ordering, inventory, bookkeeping.

Eaton Springtites are available in screw and bolt sizes and various type heads to meet your fastening assembly requirements. Use Eaton Springtites and save.

RELIANCE SPRING LOCK WASHERS . . . An effective fastening device made to insure dependable, enduring bolt tightness. A type and size for every fastening need. Write for folder.

RELIANCE RINGS produce strong, easily-assembled shoulders on shafts or in counterbores without expensive machining or waste of metal. Many cross sections, all diameters; ends shaped to meet any requirement. Write for folder.

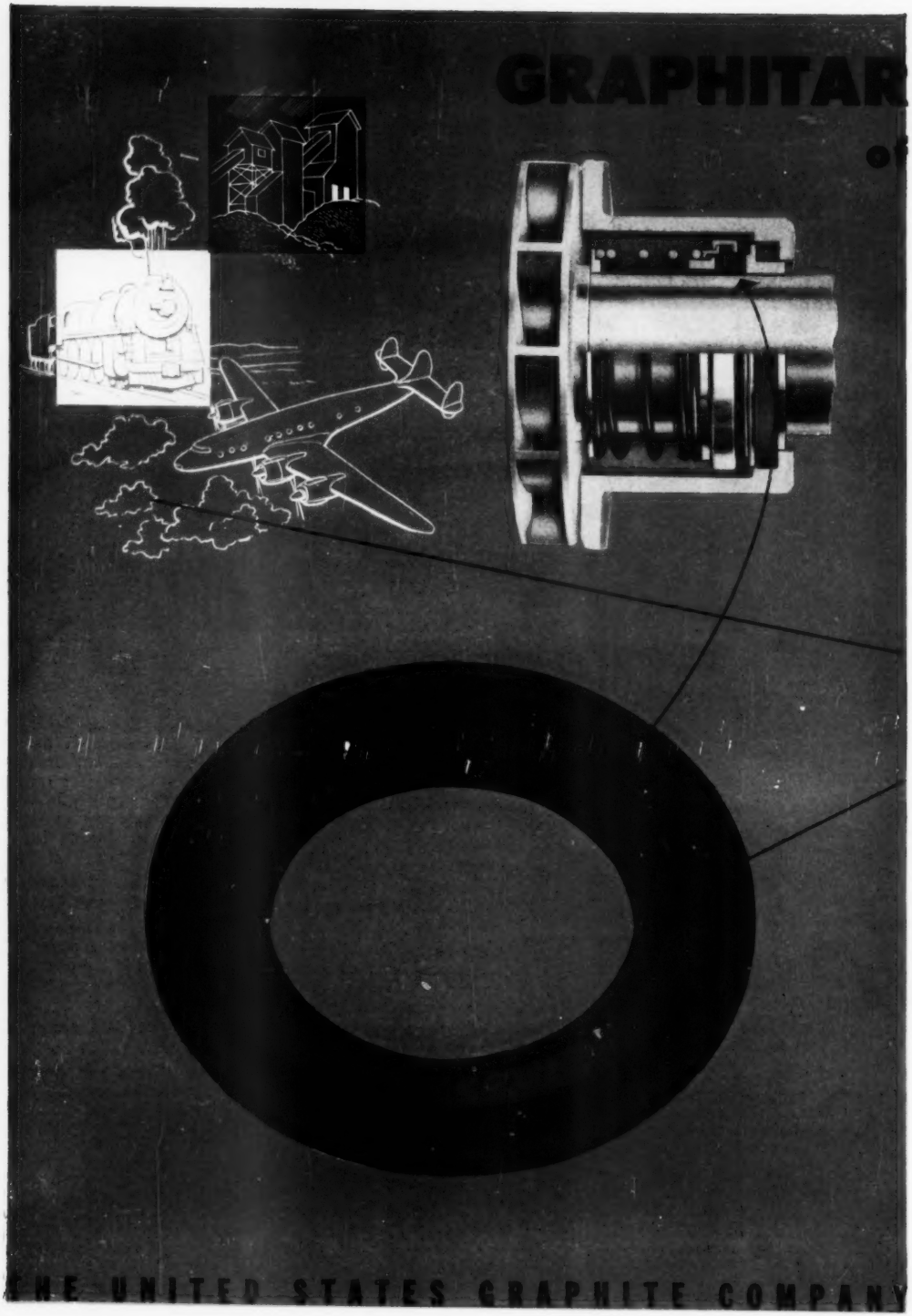
Reliance Division

OFFICES AND PLANT **MASSILLON, OHIO**

EATON

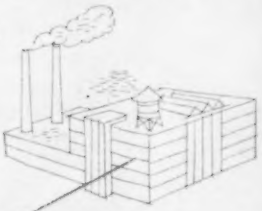
EATON MANUFACTURING COMPANY

Sales Offices: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal


GRAPHITAR
THE UNITED STATES GRAPHITE COMPANY

assures successful operation high speed liquid seals

Gits Specifies Graphitar for Oilseal Assembly To Solve High Speed Sealing Problem



● Keeping the lubricating oil separated from liquids being pumped at high speeds and pressures was a problem for the Gits Brothers Manufacturing Co. of Chicago, until they specified Graphitar for the nose piece of their oil-seal assembly for pump manufacturers. Now the Graphitar seal helps *keep pumps operating smoothly* despite operating conditions of 150 psi pressure, 4000 RPM and 150°F. temperatures.

● This is another typically difficult sealing problem that Graphitar is solving in industry today. Graphitar seals seat themselves and form a drop-tight seal under conditions that many conventional seals cannot tolerate. Graphitar *does not warp or distort under heat,* it is corrosion resistant and mechanically strong. Graphitar is a carbon-graphite product that is self-lubricating and extremely light. It can be ground to tolerances as *close as .0005" in small sizes.* Our engineers may be able to suggest Graphitar applications that will improve the efficiency of your products. Send us your prints for recommendations without obligation.

Ask for your copy of the Graphitar catalog.

GRAPHITAR

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

One man does the work of three—fastening heads on oil heaters manufactured by the Easy Heet Company of Seattle, Washington.

The gun pulls the rivet stem. Expands the rivet shank. Forms a head on the blind side

CHERRY BLIND RIVETS
MAKE THE HARD JOBS EASY

"WE ARE SAVING APPROXIMATELY 30 PER-CENT by using Cherry Rivets in place of sheet metal screws." Simple, quick assembly-line fastening with Cherry Rivets resulted in substantial labor-cost savings for this manufacturer. Highly adaptable to production-type assembly work, Cherry Rivets conform to curves, bends, and tight angles as well as to a wide range of materials. Cherry Rivets are used in Marine, Metal Signs, Railroad Shops, Aviation Plants, etc.

COMPARABLE TO SOLID RIVETS Cherry Rivets have shear values comparable to solid rivets . . . They're much easier to use in a wide range of applications . . . Only one man is needed . . . There's no "bucking" with Cherry Rivets.

VIBRATION-RESISTANT Cherry Blind Rivets have excellent hole-filling qualities and high clinching action between the shank of the rivet and the materials fastened. They hold *tight* where screws or bolts may work loose under vibration.

TAMPER-PROOF The tamper-proof qualities of Cherry Rivets add to their proved dependability. With the proper tools, however, a service representative can easily remove and replace Cherry Rivets without any change in the excellent appearance of your product.

Cherry Rivets are made from aluminum alloy, steel, or Monel. Standard rivets come in five diameters and two head styles. There is a wide range of grip lengths. Special heads, diameters, grip lengths, and alloys can be made to order. Write today for further information. Address Department A-106, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.

CHERRY RIVETS, THEIR MANUFACTURE & APPLICATION ARE COVERED BY U. S. PATENTS ISSUED & PENDING

Cherry Rivet
Company
LOS ANGELES 13, CALIFORNIA

CHERRY RIVETS ARE APPROVED BY CIVIL AERONAUTICS AUTHORITY AND UNDERWRITERS' LABORATORIES, INC.

● ENGINEERED IN PLASTICS BY GENERAL ELECTRIC

A kitchen molded in plastics

● Here's a miniature all-plastics kitchen! General Electric molded these attractive scale models of its appliances—refrigerators, ranges, dishwashers—even tiny clocks and toasters—to serve as visual selling tools for their retailers. By arranging the models according to planned layouts, customers can see how their new kitchen or laundry will look, before it is installed.

Could plastics help sell *your* products? General Electric's complete plastics service is equipped to design, engineer, and mold *any* type of plastics product to your specifications. Whatever your plastics requirements—scale models or refrigerator parts—it will pay you to consult with General Electric, one of the world's largest manufacturers of finished plastics products.

Write us for more information, or contact your nearest G-E sales office. We'll be glad to send you, free, the interesting, informative booklet, "Design Data on Plastics." Address: Plastics Division, Chemical Department, General Electric Company, 1 Plastics Ave., Pittsfield, Mass.

G-E COMPLETE SERVICE—AT NO. 1 PLASTICS AVENUE

Backed by 54 years of experience. We've been designing and manufacturing plastics products since 1894. General Electric research facilities have expanded continually, working to develop new materials, new processes, new applications for plastics parts.

No. 1 Plastics Avenue ... complete plastics service—engineering, design, mold-making. G-E industrial designers work with our engineers to create plastics parts, sound and good looking. Skilled mold-makers in G-E toolrooms average over 13 years experience.

All types of plastics. Compression, injection, transfer and cold mold facilities...high and low pressure laminating . . . fabricating. G-E Quality Control—a byword in industry, means as many as 160 inspections and analyses for a single plastics part.

GENERAL ELECTRIC

CD49-D1

General Electric plastics factories are located in Scranton, Pa., Meriden, Conn., Coshocton, Ohio, Decatur, Ill., Taunton and Pittsfield, Mass.

PNEUMATIC TIMERS

THESE PROVEN ADVANTAGES OF A.C. DESIGN NOW FEATURED IN NEW D.C. TIMERS

- **ACCURATE**—less than 10% variation, plus or minus, from mean timing period. Unaffected by normal changes in voltage and ambient temperature.
- **WIDE RANGE**—timing period adjustable from 0.2 seconds to 3 minutes.
- **EASY TIMING ADJUSTMENT**—quick finger-tip setting of knurled knob or micrometer dial.
- **SNAP ACTION CONTACTS**—normally open and normally closed in self-contained, arc-resistant melamine case—rated for A.C. or D.C. control circuits.
- **ELECTRICAL INTERLOCKS**—operated by the magnet which actuates the timing mechanism—frequently eliminates need for additional switching relays.

SQUARE D COMPANY

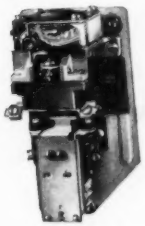
DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

FOR EVERY JOB
A. C. OR D. C.

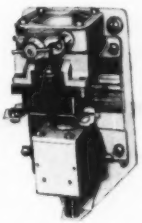
Applications: Timing motor acceleration, machine sequences, process industry operations, resistance welds and dozens of similar functions.

Square D's wide variety of A. C. and D. C. timers enables you to select exactly the right one for any given job.

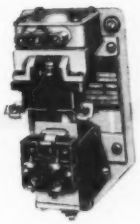


A. C. Time delay after de-energization. Micrometer dial.

A. C. Time delay after energization. Electrical interlock.

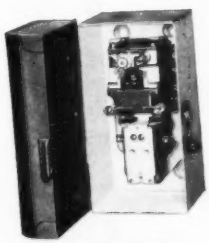


D. C. Time delay after energization. Micrometer dial.



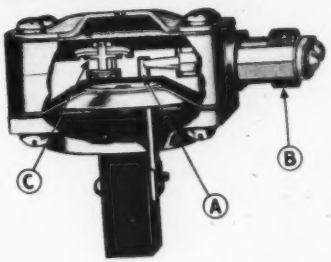
D. C. Time delay after de-energization. Electrical interlock.

Flush mounting plate.



General purpose enclosure.

THIS BASIC PNEUMATIC TIMER UNIT FEATURED IN ALL THESE TIMERS

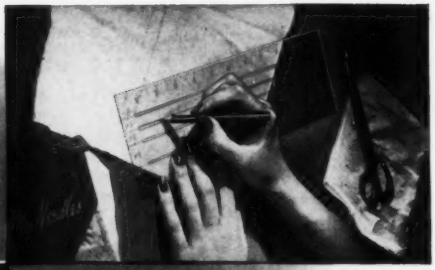


HOW IT WORKS: Simple operating principle is based on the interval required to transfer a small volume of filtered air from upper to lower chamber through a regulated orifice (**A**). Rotation of knurled knob (**B**) gives wide range of adjustment. Air returns through valve (**C**) for instantaneous reset.

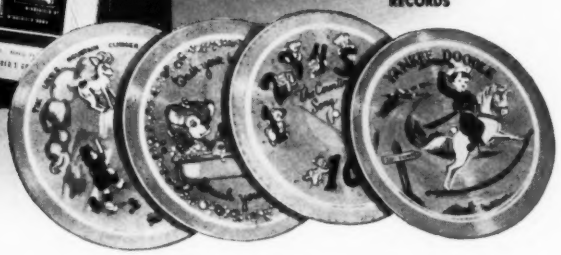
***Write* for Bulletin 9050. Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin**

PRICE-TICKET HOLDERS

COUNTER DISPLAYS



MARKERS—RULERS



RECORDS

ORNAMENTS

RIGID SHEETS—FOR FLEXIBLE MINDS!

Imaginative thinking, with all facts at hand, led to the making of these fine products from VINYLITE Plastic Rigid Sheets!

They have an almost unbelievable *formability*, even for complicated, three-dimensional shapes. They are strong, tough, and stiff, so that parts molded from them are amazingly *stable*, holding their form and dimensions despite exposure to water and changes in weather, most strong acids, alkalis, and other chemicals, as well as to temperatures up to 55 deg. C.

Perfectly registered printing in four or more colors is readily accomplished, and the material also accepts embossing or any etched or intaglio design.

The easy workability of economical VINYLITE Rigid Sheets by simple, unspecialized methods has made them highly favored plastic materials among shop men and design engineers, alike. They come in all colors—or clear. They may be transparent, translucent, or opaque, with a glossy-smooth polished, or matte, surface. They will not support combustion.

Find out more about VINYLITE Plastic Rigid Sheets by writing Department EN-10.

DOLL FACES

- RADIO DIALS
- TRANSPARENT PACKAGES
- PLACE MATS
- AIRPLANE WINDSHIELDS
- ELECTROTYPE MOLDS
- PLAYING CARDS
- ACID-PIPE LABELS

Vinylite BRAND PLASTICS

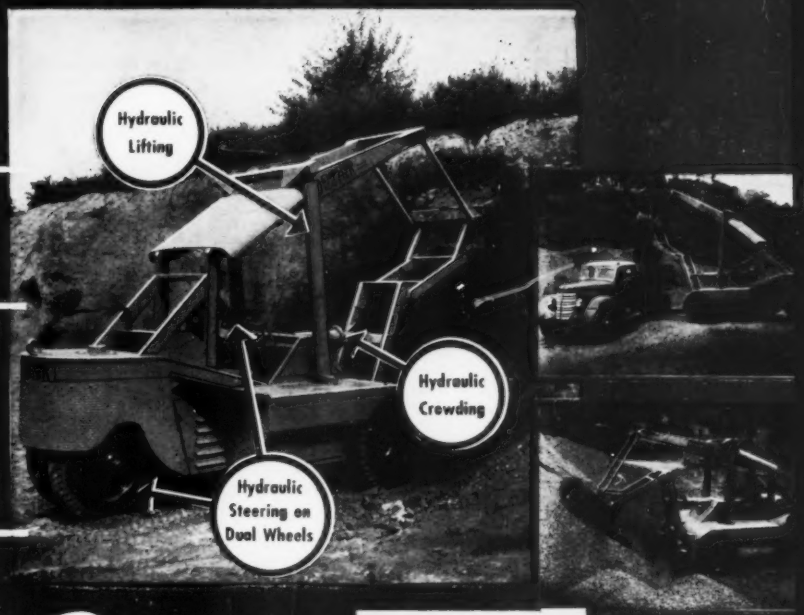
BAKELITE CORPORATION

BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.

fast

mobile

easy to operate



Dempster-Diggster

Has VICKERS HYDRAULIC CONTROLS

High speed versatility (as exemplified by the Dempster-Diggster) is characteristic of Vickers Hydraulic Controls.

Vickers Hydraulic Power Steering Booster makes it easier to steer the Dempster-Diggster over rough terrain, than a passenger car on smooth pavement. Steering load is carried by hydraulic cylinder . . . not by the driver.

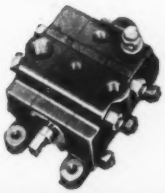
Vickers Balanced Vane Type Pumps supply oil under pressure also for actuating cylinders that lift and crowd the dipper. These pumps are exceptionally efficient and dependable; their exclusive hydraulic balance construction prolongs pump life by entirely eliminating pressure-induced loads and consequent wear.

Overload protection for the machine is provided by relief valves integral with Vickers Steering Booster and Valves. Write for descriptive bulletins.

Vickers Improved Hydraulic Steering Booster with integral overload relief valve. See Bulletin 47-30a.

Vickers Balanced Vane Type Pumps are engine driven. See Bulletin 36-12.

Vickers "Multiple Unit" Valves include relief valve for overload protection. See Bulletin 40-13.



VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION

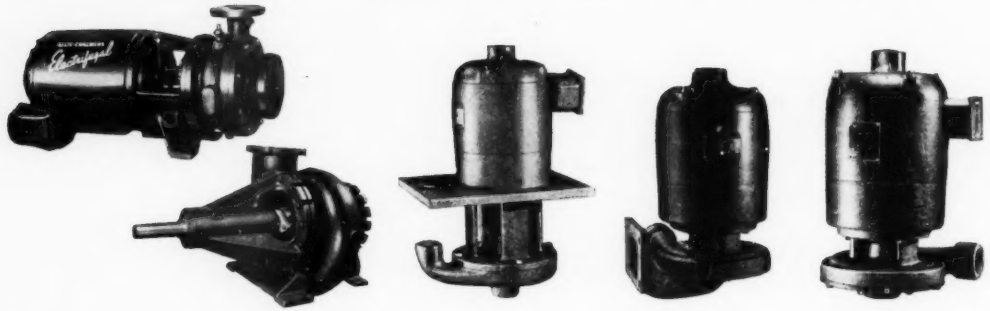
Application Engineering Offices:
ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT
LOS ANGELES • NEWARK • PHILADELPHIA • PITTSBURGH • ROCHESTER
ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

ALLIS-CHALMERS OFFERS EQUIPMENT

Looking for a

SELECT FROM THE COMPLETE ALLIS-CHALMERS LINE 10 GPM TO ANY SIZE!



ELECTRIFUGAL — Sturdy package type unit. Pump brackets and flange integral with frame. Capacities 10 to 1600 gpm, heads to 525 ft. Horizontal or vertical mounting.

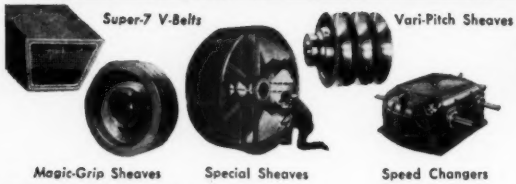
TYPE CW — Use wherever large amounts of suspended solids are to be circulated. Only 5 working parts! Wearing parts easily replaced. Capacities to 7000 gpm, heads to 100 feet.

TYPE RHV — For general service — where no abrasives are handled. Vertical operation with flooded suction. Has single suction enclosed impeller. Range to 97 gpm, 90 ft. head.

TYPE CR — General service pump mounts in horizontal, vertical, or angle position. Flexible mechanical seal automatically compensates for wear. Range to 80 gpm, heads to 100 feet.

TYPE CRV — For general service where no abrasives are handled. These are sealed, single suction, open impeller, sidewall mounted pumps. Range to 80 gpm, 60 ft. head.

Electrifugal, Texrope, Super-7, Texiron, Texsteel, Texdrive, Magic-Grip, and *Vari-Pitch* are Allis-Chalmers trademarks.



Texrope V-Belt Drives

Quick delivery on all standard V-belt sizes and lengths. For constant speed drives, complete line of Texiron, Texsteel, Texdrive, Magic-Grip, standard or special cast iron or steel sheaves for section A, B, C, D, and E belts. For adjustable speed drives, Vari-Pitch sheaves give 100% speed range. Vari-Pitch Speed Changers, 375% speed range.

Motors — ½ hp To The Largest

Shown are a few of the many motor types available to designers from Allis-Chalmers broad motor line. For tough operating conditions, use enclosed, fan-cooled induction motors. Dust, dirt, acid fumes, or moisture in the cooling air passes around the stator structure without coming in contact with the windings.

Sold — Applied — Serviced by Authorized Dealers, Certified Service Shops, and District Offices Throughout U. S.

ALLIS-

AID TO MACHINE DESIGNERS!

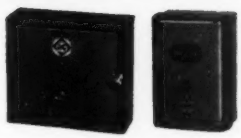
Quality Pump?

TYPE R — A general service pump of foot mounted type. Pump has shaft seal, and enclosed impeller. Sizes range to 80 gpm, heads to 100 feet.

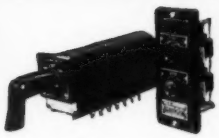
TYPE KW — A new sealless, double suction, open impeller type. Two lengths for various tank depths. Range to 97 gpm, heads to 90 feet.

TYPE HHV — Vertical, submerged, seal-less pump. Single suction. Mounting plate cast integral with adaptor. Range to 97 gpm, heads to 90 ft.

TYPE KF—Double suction, sealless, open impeller pump for handling liquids containing chips or abrasives. Range of sizes to 97 gpm, 90 ft. head.



Motor Starters



Rotary Control and Push Buttons

Controls — Any Type or Size

Across-the-line starters for a-c motors range from size 0 to 7. Also manual or magnetic, full or reduced voltage starters for any industrial application. Standard, dust-tight, water-tight, and explosion-proof enclosures. Control devices include standard and heavy duty push button stations, rotary switches, voltage regulators, contactors and relays.

ALLIS-CHALMERS, 1002A SO. 70 ST. A 2466
MILWAUKEE, WIS.

Please send me:

- ☐ Handy Guide to Electric Motors (51B6052H
- ☐ Handy Guide to Centrifugal Pumps (53B6059D)
- ☐ Handy Guide to Texrope Drives (20B6051H)
- ☐ Variable Voltage Planer Drives
- ☐ Equipment for Machine Tools (25B7110)
- ☐ D-C Remote Indications and Controls (14B6641)
- ☐ Coolant Circulating Pumps (52B6975)
- ☐ General Purpose Motor Controls (14B7132)

Name.....

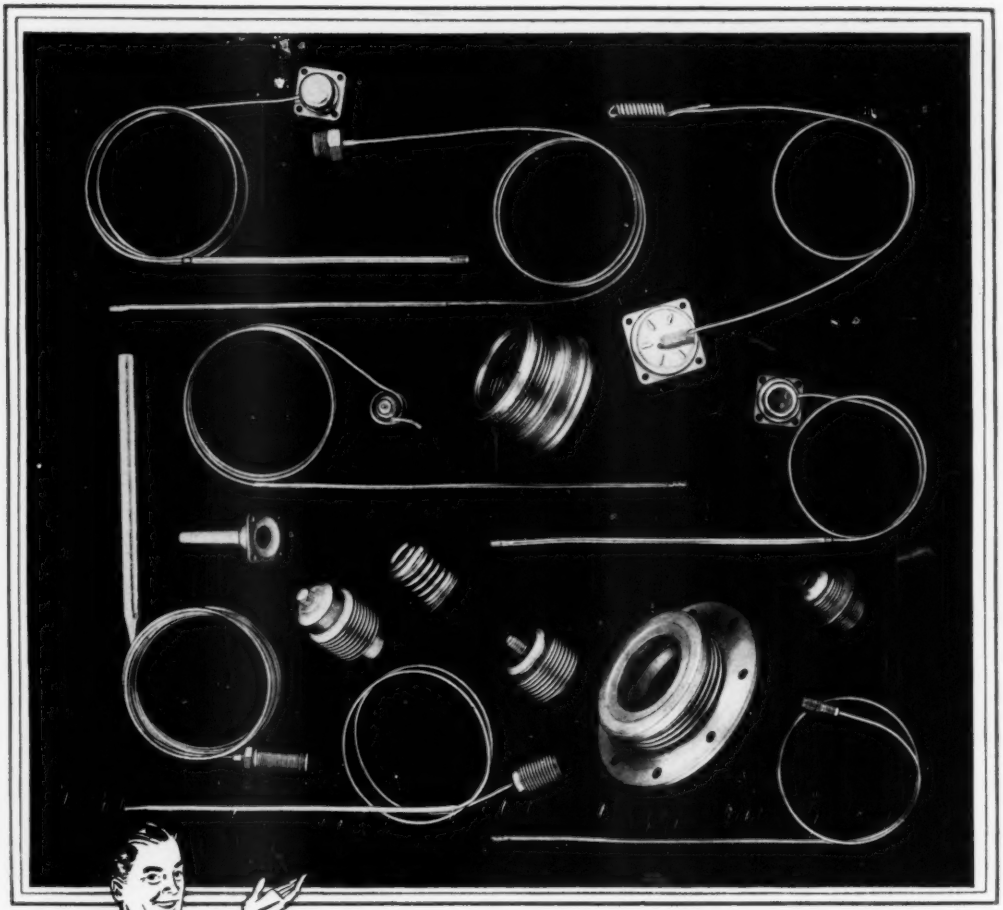
Company.....

Street.....

City.....State.....

ALLIS-CHALMERS MILWAUKEE A-C

CHALMERS



Each of these
BELLOWS ASSEMBLIES *was a different problem. How different is yours?*

If you merely suspect that a bellows assembly can do your job, you're in the same position where some of our most satisfied customers started. Our engineering department will be glad to analyze *your* problem, too. Send *your* sketches and specifications for confidential study and recommendations. There is no obligation.

CLIFFORD MANUFACTURING COMPANY, 564 Grove Street, Waltham 54, Massachusetts. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago and Los Angeles.

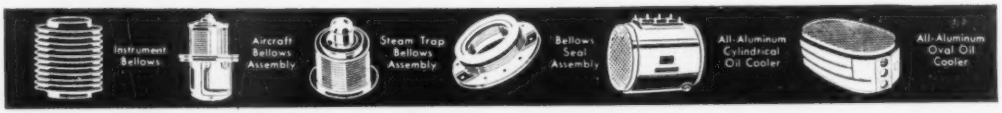
First with the Facts on Hydraulically-Formed Bellows

CLIFFORD

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

HYDRON Metal Products



EATON PERMANENT MOLD
GRAY IRON CASTINGS
for
Pulleys and Sheaves
Uniform structure throughout the casting, freedom from growth and segregation, plus good tensile strength and ability to take a high surface finish—these qualities make Eaton Permanent Mold Gray Iron Castings ideal for the production of V-belt pulleys, sheaves, and similar parts. Free machinability makes for maximum production speed and low machining cost.
Eaton Foundry Division engineers will be glad to discuss the application of Eaton Permanent Mold Gray Iron Castings to your product. Send for your copy of the illustrated booklet, "A Quick Picture of the Eaton Permanent Mold Process for Producing Gray Iron Castings".
EATON
MANUFACTURING COMPANY
FOUNDRY DIVISION
9771 French Road · Detroit 13, Michigan

Nash CHOOSES GRAMIX

When Nash engineers designed the smooth performing new 1949 Ambassador and "600" Airflyte models, they specified Gramix bearings for four important engine accessory functions. Engineers choose Gramix because *it is self-lubricating*. Gramix is die-pressed of powdered metals — a porous product that retains the lubricant and releases it as the moving parts require. And because Gramix bearings require no machining, they can be produced at a fraction of the cost of ordinary machined bearings. A study of your plans may reveal where Gramix can simplify a production problem and reduce manufacturing costs. Send us a drawing or description of parts you use and our engineers will gladly make suggestions that may be to your advantage.

THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN

DIVISION OF THE WICKES CORPORATION

Auten Ready Case molded for Auten Manufacturing Co., Princeville, Illinois

A Case of Convenience

We enjoy working with new ideas. They present a stimulating challenge to our engineering and molding skill. For example, take this Auten Ready Case, an idea typifying GI ingenuity. Its inventor, while stationed in the Philippines, conceived it as a way to conveniently handle matches, cigarettes and cigarette case at the same time. Our objective was to mold a case with sales-winning eye appeal that matched its increased functional appeal. To this end we applied our inflexible production formula—correct use of the right plastic material—skillful use of the most effective molding technique. Why not discuss your new product idea with us? If its production lends itself to our injection molding or extrusion technique we will assure you a product of peerless quality. Consult us without obligation.

Write on your letterhead for the new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about Chris-Plastic* *piping, tubing and fittings, write for circulars containing data and illustrations.*

**Trademark Registered*

ELMER E. MILLS CORPORATION

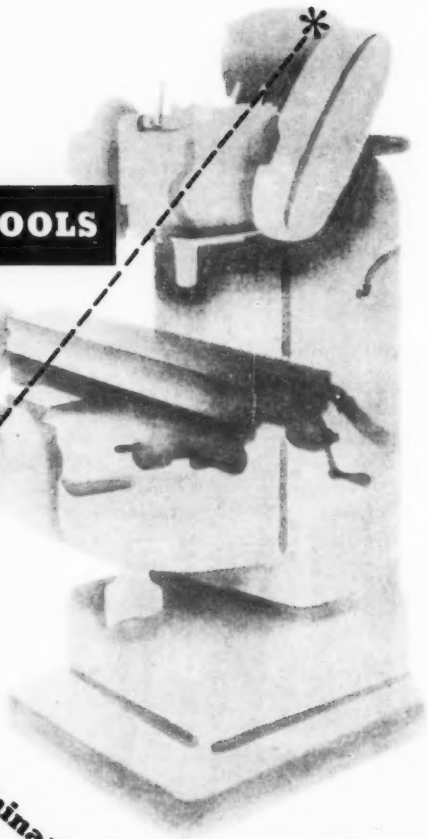
INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Fibestos, Lucite, Plexiglas, Nylon, Polystyrene, Styron, Lustron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Cerex, Forticel, Chris-Plastic*, Saran, and other Thermoplastic Materials

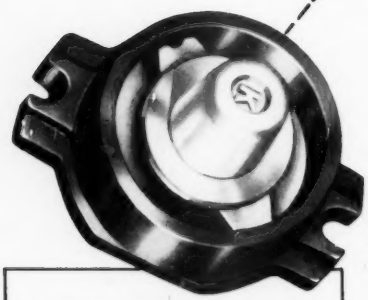
2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS

IN MOTORS FOR MACHINE TOOLS

KLIXON PROTECTORS

Keep Equipment Operating by Eliminating Motor Burnouts





One of the major causes of motor burnouts in machine tools is overloading of the machine. This causes the motor to dangerously overheat and burnout.

You can keep production going and reduce down time of lathes, drills, milling machines, etc., by specifying and using motors with built-in Klixon Protectors.

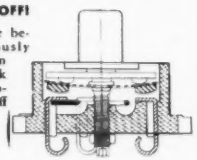
Because Klixon Protectors are built-in by the motor manufacturer and placed where they can watch overheating, they prevent the motor from burning out by cutting off the power as soon as the motor reaches a dangerous temperature. When it cools to safety, the protector snaps on the power again either automatically or by manual reset depending on the type of protector used.

Remember, too, Klixon Protectors prevent burnouts in other equipment such as transformers, solenoids, and adjustable transformers. So to keep your equipment operating, always use motors with Klixon Protectors.

HERE'S HOW IT WORKS

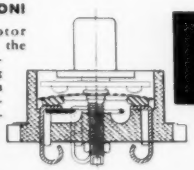
CLICK . . . IT'S OFF!

Should a motor become dangerously overheated from any cause, click the Klixon Protector snaps off the power automatically.



CLICK . . . IT'S ON!

When the motor cools to safety, the circuit is re-established by pressing the red button on the manual protector or automatically when the automatic type is used.



KLIXON

SPENCER THERMOSTAT COMPANY

901 FOREST STREET, ATTLEBORO, MASS.

Micarta TAKES A DEEP DRAW TO SAVE YOU MONEY

When you need a tough, deep-drawing material for limited quantities—check Micarta. Deep, 24-inch draws, like the one illustrated below, are everyday jobs. Micarta, no ordinary "plastic" : : : is today's tough, versatile, industrial laminate. It has proved itself in thousands of industrial applications.

Besides formability, Micarta has other characteristics which make it the No. 1 industrial laminate:

HIGH STRUCTURAL-COMPRESSIVE STRENGTH—it is half the weight of aluminum for the same comprehensive strength.

HIGH DIELECTRIC STRENGTH—equivalent to mica, one of the best insulators.

HIGH HEAT RESISTANCE—easily withstands heat up to 230°F. Below zero it gains in strength without brittleness.

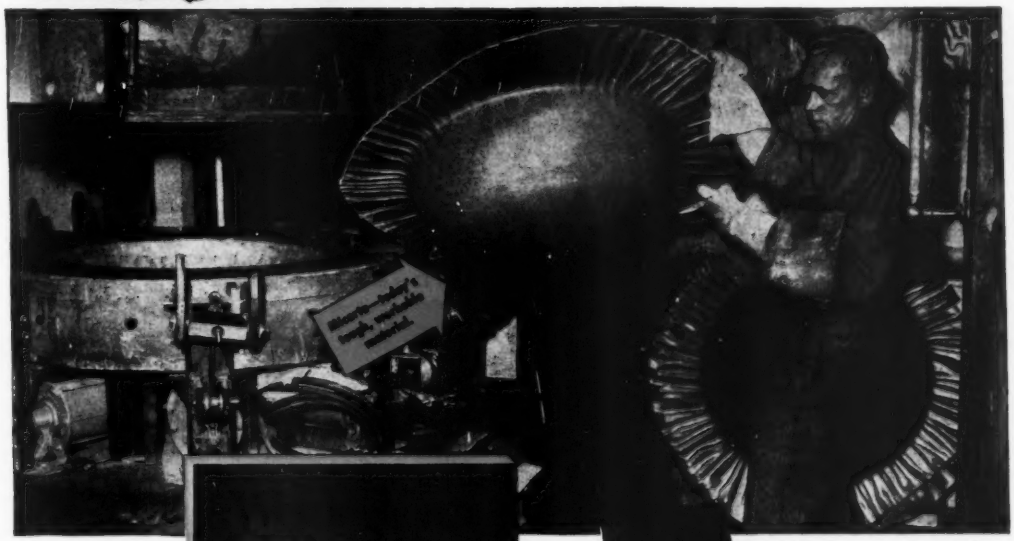
HIGH RESISTANCE TO ACIDS, ALKALIES—to 10% solution.

HIGH WORKABILITY—you can drill, tap, mill, die, punch, saw like a metal.

YOU CAN BE SURE.. IF IT'S Westinghouse

Micarta is available molded, formed or completely fabricated—in *mass production quantities*. Remember Micarta for a tough job...call your Westinghouse office for a Micarta Specialist. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna.

J-06402-A



Send for this new Micarta Data Book, today. Ask for B-3184-B.

If you start with a
LUKENS HEAD-SHAPE
YOU SAVE 3 WAYS

You save on die costs—By selecting a standard Head-Shape from Lukens Catalog No. 1, you avoid any expense for forming tools. And even where the shape varies somewhat from standard, Lukens often has dies on hand which can be quickly and inexpensively adapted to produce it.

You save time—Many standard Lukens Head-Shapes are in stock, ready for prompt shipment. Others can be produced from our huge stock of dies.

You boost production—Because Lukens has already done the initial forming operations, you by-pass those first steps and get right to work finishing the parts. Your facilities and labor normally required here are released for other manufacturing work.

Lukens makes Head-Shapes as small as four inches and to over twenty feet in diameter; as thick as six inches. They are made in all commercial metals: carbon and alloy steels, including stainless, or nonferrous metals and the widest selection of clad steels available anywhere.

For a copy of Catalog No. 1 describing 3,868 standard Head-Shapes, or of Bulletin 433 listing stock heads, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

LUKENS HEADS

"HEAD WORK", a 16mm motion picture in sound and color, on spinning and pressing of Lukens Heads is available without charge. Running time: 27 minutes. Write for a booking date.

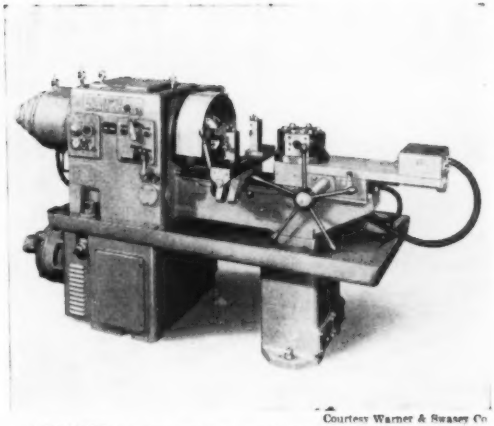
FOUR INCHES TO OVER TWENTY FEET IN DIAMETER

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

What happens—

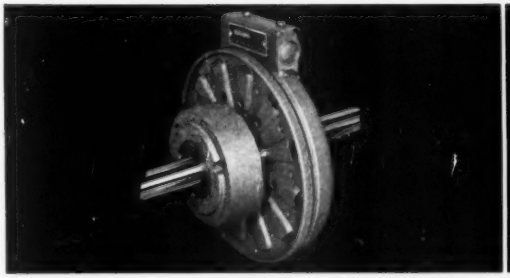
When You Give A Turret Lathe A

BRAKE?

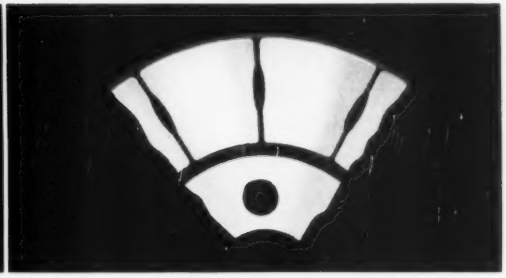


Courtesy Warner & Swasey Co

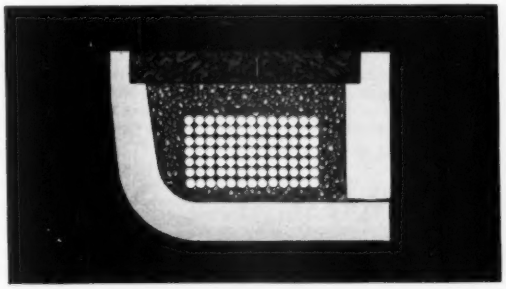
ANSWER: You reduce machine handling time and increase production because you get fast, more fully automatic cycle operation. The W & S 16" Electro-Cycle turret lathe, especially designed for machining non-ferrous metals, uses the Warner Electric Industrial Brake. It gives lightning fast spindle stops and closer spindle positioning — that means fast load and unload of workpieces.



THE BRAKE: Note compact design . . . readily adapts to machine or motor. Unit consists of only two parts . . . one fixed and one moving. Brake is automatically self-adjusting for life. Wide range of sizes to meet various requirements. Fits N.E.M.A. standard motor shafts.



ARMATURE SECTION: Armature is only moving part. Consists of magnetic material segments welded to steel back plate . . . for unmatched heat dissipation. Heat has no effect on efficiency . . . segment expansion is linear . . . keeps full magnet contact at all times.



MAGNET SECTION: Unique electro-magnet faced with extra long-wearing, molded friction material. Power is applied through coils imbedded below. Energizing applies friction *plus* magnetic attraction for super-powerful braking or clutch action.

• Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

*ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

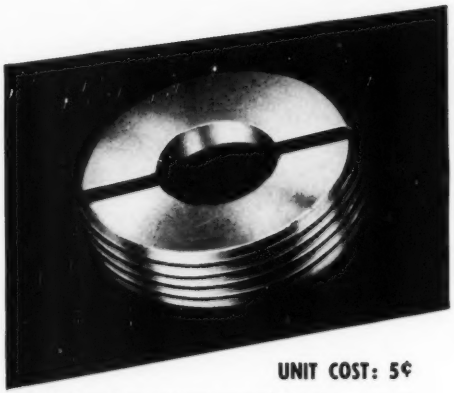
When You Want New Ways to

NO MORE COSTLY HAND WORK...

Excessive burring during machining caused rejects, or expensive hand work to "salvage" the parts from the scrap heap. Because of the change to Carpenter Free-Machining Stainless, the burring problem disappeared and fishing reel parts are produced faster, at less cost.

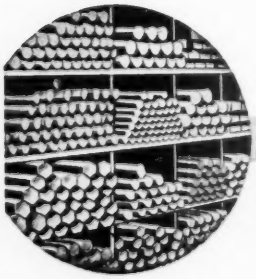
You Can Turn It Out
AT LESS COST
with Carpenter Free-Machining Stainless!

The cost of the steel you buy is only a fraction of the cost of the finished products made from Stainless. To get a lower *unit* cost for every Stainless part you make, take advantage of the help that Carpenter can give you.



UNIT COST: 5¢

Production slow—rejects excessive and unit costs "impossible" until Carpenter Stainless No. 8 (Type 304) was used for making this bearing race. Unit cost is now only 5¢...tool life has more than doubled and rejects have dropped 40%.



WHEN YOU WANT *Rush* DELIVERY CALL YOUR *Carpenter* WAREHOUSE -

BOSTON	CINCINNATI	HARTFORD	PHILADELPHIA
BRIDGEPORT, CONN.	CLEVELAND	INDIANAPOLIS	PROVIDENCE
BUFFALO	DAYTON	LOS ANGELES	ST. LOUIS
CHICAGO	DETROIT	NEW YORK	WORCESTER, MASS.

SEE THE CLASSIFIED SECTION OF YOUR TELEPHONE DIRECTORY

REDUCE MACHINING COSTS on STAINLESS Jobs

—use this *Carpenter* help!

Our help starts with the *uniformity* of the free-machining Stainless you buy from your Carpenter warehouse. Every lot machines the same, to the finish you want.

Next, Carpenter's STAINLESS MACHINING "NOTEBOOK" gives correct information on speeds, feeds, tooling, etc. for all types of jobs. Each chapter contains a Check Chart that lists common "trouble spots" and gives shop tips on how to cure them. Many plants have reported better results and reduced costs after putting this information to work. For your personal copy of the Carpenter "Notebook on Machining Stainless Steels", send us a note on your company letterhead, indicating your title, please. Extra copies of the NOTEBOOK, for the men in your shop, are available at 50¢ each.

Using Carpenter's SHOP HELP ON NEW JOBS is another way to bring down the cost of working with Stainless, where special requirements and extremely close tolerances are important. Combine your nearby Carpenter representative's experience with easy-to-work Carpenter Stainless bars, and you have a large part of the answer to low cost machining on your Stainless jobs. To put that experience to work in your plant—at a saving—get in touch with the nearest Carpenter office listed below.

MORE PARTS PER DAY . . .

Actual time records show an increased number of parts per day, flawless finishes and longer tool life now that Carpenter Stainless No. 8 (Type 303) is used for these corrosion-resistant valve needles.

TOTAL TOLERANCE .0005"

And a hole is reamed (without grinding) to minus .0000", plus .0002" for this spiral gear. Even if you do not work to tolerances such as these, the job is a good example of what *can* be done—at a profit—when you use Carpenter Free-Machining Stainless.

more than corrosion resistance

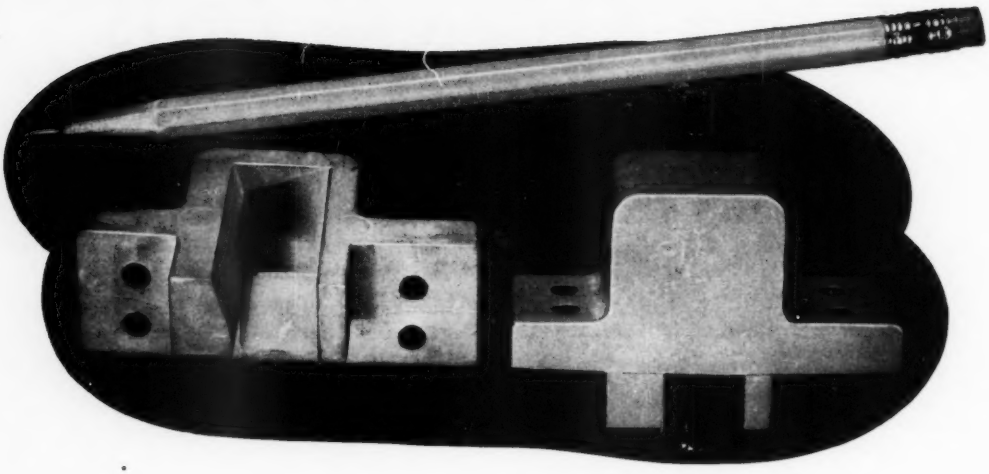
THE CARPENTER STEEL COMPANY, 117 West Bern Street, Reading, Pa.

Export Department: 233 Broadway
New York 7, N.Y. "CARSTEELCO"

Carpenter

FREE-MACHINING

STAINLESS STEELS



Design problem –solved in one operation

There is a story behind this picture worth several thousand dollars to one manufacturer. It may be worth a tidy sum to you, too.

Looking at the picture you see two life-size views of a Monel part used in quantity by this machinery manufacturer.

Just make a quick estimate as to what you would expect to pay for it. Consider the cost of the forging dies... broaching the slot... silver-soldering the back plate to close the end... drilling four bolt holes... and facing the back flange to fit the curved contour of a cylinder.

Something around $3.25, wouldn't you say?

Actually, this manufacturer is getting these parts exactly as you see them for just about a third less than you estimate.

How? By precision casting. One operation, one piece – and there you have the finished part all ready to bolt on the machine.

That is just one example of the variety of different parts now being produced in INCO's new Precision Casting Plant. The beauty of precision casting is the way its versatility opens up new possibilities for quantity-producing metal parts in designs too intricate to fabricate economically by conventional methods or downright impractical to produce by any other method.

INCO Nickel Alloys

Monel • "R"* Monel • "K"* Monel • "KR"* Monel • "S"* Monel*
Nickel • "L" Nickel • "Z"* Nickel • Inconel* *Reg. U.S. Pat. Off.*

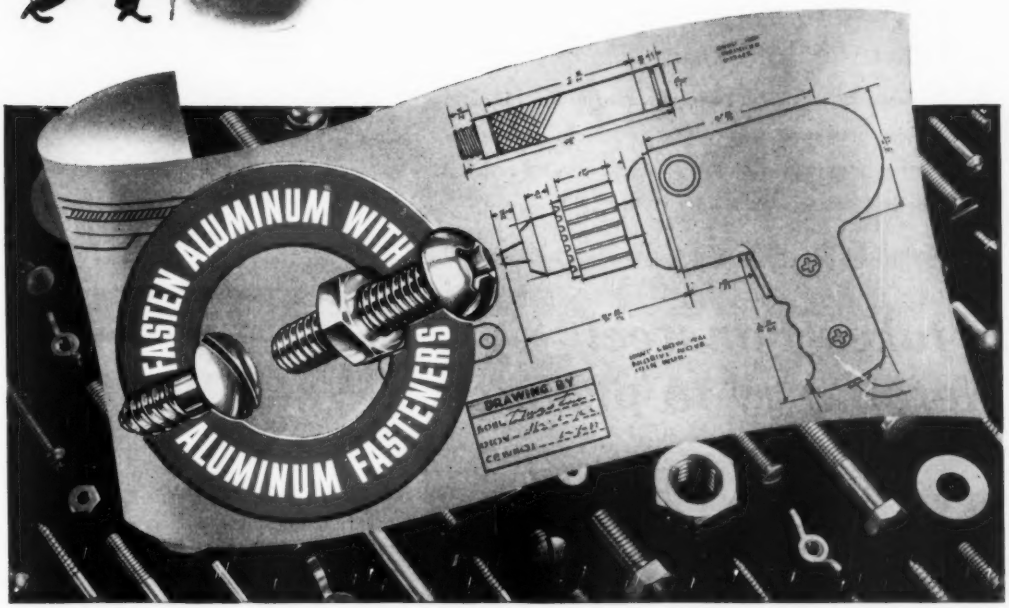
"Task Metals" for Industry

EMBLEM OF SERVICE
INCO
TRADE MARK

IF YOU HAVE A PROBLEM *with a part whose cost seems too high... or a part where a precision casting might eliminate a number of operations (as with this latch-keeper)... or a part whose design cannot be practically worked out via other methods... send us a sample or blueprint, along with the approximate quantity needed. Within a few days you'll receive our frank answer telling you whether or not precision casting offers a better solution. Address your letter to our Bill Calnan.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N.Y.

AVOID "JOINT TROUBLE" IN ALUMINUM ASSEMBLIES



SPECIFY ALCOA ALUMINUM FASTENERS

right on your drawings!

WRITE FOR FREE SAMPLES

of the types that interest you. And phone your nearest Alcoa sales office or Alcoa distributor for prompt service. ALUMINUM COMPANY OF AMERICA, 618 Gulf Building, Pittsburgh 19, Pa.

There's no need to run the risk of the galvanic corrosion that can come when aluminum is fastened with dissimilar metals. The complete line of Alcoa Aluminum Fasteners includes all the types required to meet any production assembly need.

Complete ranges of sizes and head types. Slotted or Phillips head. Made to Alcoa quality standards, yet not expensive.

ALCOA *Aluminum* FASTENERS

Fastell® (trade name of a group of highly specialized powder metallurgy compositions, made exclusively by Fansteel) combines the high melting point, low arcing and non-welding properties of high refractory metals such as tungsten* or molybdenum* with the high conductivity and low surface resistance of silver or copper. These metals are not alloyed, not merely bonded, but *integrated* by Fansteel techniques in correct proportions for heavy duty electrical contact service.

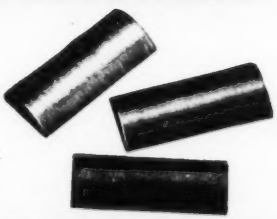
With the correct Fastell contacts, your product is assured against premature failure due to arcing, against overheating or voltage drop due to contact surface resistance. Fansteel engineers are at your service.

Fansteel Metallurgical Corporation, North Chicago, Ill.

for

Heavy

Duty



Services

It takes Fansteel Metallurgy to produce

Fastell®
ELECTRICAL CONTACTS

*Melting Points: Tungsten 6152°F, Molybdenum 4757°F.

A complete coverage of Fansteel Electrical Contacts for all services is provided in this manual. Ask for your copy.

Fansteel
ELECTRICAL CONTACTS and CONTACT ASSEMBLIES

Do you need immediate delivery from warehouse stock?

52100 TUBING

HIGH CARBON CHROME STEEL — A DIRECT QUENCHING STEEL WHICH GIVES THROUGH-HARDNESS IN MODERATE SECTIONS.

Typical uses:

aircraft parts — *bushings*
slitter knives — *spindles*
bearing races — *grinding machines*
collets — *precision instruments*
bump parts and plungers

"NICKEL-MOLY" TUBING

LOW CARBON NICKEL-MOLY STEEL— A CARBURIZING STEEL WHICH GIVES HIGH SURFACE HARDNESS WITH A TOUGH CORE.

Typical uses:

piston pins — *sleeves*
bearing races — *bushings*
farm equipment — *pump parts*
knitting machinery — *perforating guns*

These two TIMKEN® wear-resistant tubes will do 90% of your hollow parts jobs!

You can get the steel tubes you need for 90% of your hollow parts jobs right now. Timken 52100 and Timken "Nickel-moly"—two general purpose steels with good hardenability and wear resistance—are available for immediate delivery in small quantities within 24 hours after receipt of your order! Between them, they have the properties nine out of ten hollow parts jobs require.

Timken 52100 can often be used in place of more expensive steels. It can be heat treated to file hardness and tempered back to any desired point. In moderate sections it is through-hardening. There are 101 sizes of 52100 tubing, from 1″ to 10½″ O.D.

Timken "Nickel-moly" has exceptional stamina and shock absorbing qualities. It is a low carbon, carburizing steel that develops high case hardness and a tough inner core. "Nickel-moly" comes in 48 sizes—1.389″ to 7.915″ O.D.

Used in place of bar stock, these two steels save both material and machining time. And they give you uniformity from tube to tube and order to order. For stock lists, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

Quickest way to your destination—correctly made springs—is *via Wallace Barnes*. Here you will be guided past the detours of costly extra operations or unnecessary handling. Here are many opportunities for production economies—in choice of material for easier forming—new ways of testing and inspection—automatic control of finishing operations. Wallace Barnes will help you—in advance—to avoid bad construction. Drive in, soon.

Wallace Barnes SPRINGS

SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

WALLACE BARNES COMPANY
BRISTOL, CONN.

DIVISION OF THE ASSOCIATED SPRING CORP.
AND IN CANADA, THE WALLACE BARNES CO., LTD., HAMILTON, ONTARIO

SHARONSTEEL

GALVANITE

A SPECIAL SHARON STEEL FOR USE IN THE MANUFACTURE OF PRODUCTS THAT CAN'T BE BROUGHT IN OUT OF THE WEATHER

Galvanite is a special zinc-coated high quality steel developed specifically for severe forming and drawing applications where rust and corrosion resistance are prime requisites.

The zinc coat is perfectly bonded with quality Sharon strip to form a surface that will not peel, flake or powder. Galvanite has a mat surface that provides the ideal base for painting and baked enamel finishes.

Galvanite is available in long coils or cut lengths, packaged on blocks or skids for economical handling.

SHARON STEEL CORPORATION

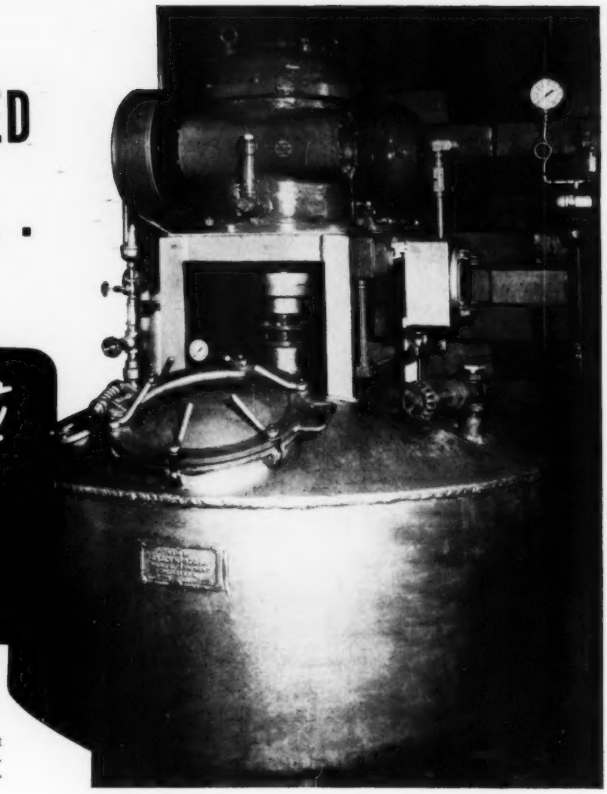
Sharon, Pennsylvania

ODUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL COMPANY, TROIT, MICHIGAN; BRAINARD STEEL COMPANY, WARREN, OHIO; SHARONSTEEL PRODUCTS COMPANY, DETROIT, MICHIGAN, AND FARRELL, PENNSYLVANIA; RPENTERTOWN COAL & COKE CO., MT. PLEASANT, PENNA.; FAIRMONT COKE WORKS, FAIRMONT, W. VA.; MORGANTOWN COKE WORKS, MORGANTOWN, VA. Hot and Cold Rolled Stainless Strip Steel—Alloy Strip Steel—High Carbon Strip Steel—Galvanite Special Coated Products—Cooperage Hoop—Detroit Seamless Steel bing—Seamless Steel Tubing in Alloy and Carbon Grades for Mechanical, Pressure and Aircraft Applications—Electrical Steel Sheets—Hot Rolled Annealed and Deoxidized Sheets—Galvanized Sheets—Enameling Grade Steel—Welded Tubing—Galvanized and Fabricated Steel Strip—Steel Strapping, Tools and Accessories.

STRICT SALES OFFICES: Chicago, Ill., Cincinnati, O., Cleveland, O., Dayton, O., Detroit, Mich., Indianapolis, Ind., Milwaukee, Wis., New York, N. Y., Philadelphia, Pa., Rochester, N. Y., Los Angeles, Calif., San Francisco, Calif., St. Louis, Mo., Montreal, Que., Toronto, Ont.

ABBOTT SPECIFIED MONEL-CLAD . . . .

because it doesn't do something



Monel-Clad Steel malt syrup mixing tank at Abbott Laboratories, North Chicago, Ill. Fabricated by Groen Mfg. Co., of Chicago.

Monel has no effect on the vitamins contained in the malt syrup handled in this tank. That's why Lukens 10% Monel-Clad Steel was used here; to safeguard the potency of products produced by Abbott Laboratories.

Other industries specify Lukens Clad Steels for a similar reason. These corrosion-resistant surfaces preserve beer's fine flavor, color and clarity.

Lukens Clad Steels present a corrosion-resistant surface of nickel, stainless steel, Inconel or Monel to protect materials coming in contact with it and to lengthen the life of the equipment itself. A uniform cladding, 10% or 20% of total plate thickness, is permanently bonded to a steel backing plate, providing *solid* corrosion-resistant metal properties at the lower cost of *clad* steels.

Lukens makes the most complete range of clad steels available from any source. Plates as thick as 3 inches or as wide as 178 inches, in the extra smooth, easy-to-clean sodium hydride finish, are available. Bulletins 255 and 338 tell you about them. For copies, write Lukens Steel Company, 405 Lukens Bldg., Coatesville, Pa.

LUKENS
Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

HERE'S on-the-job Proof of Westinghouse Instrument Performance!

Universal Tube Test Station—model 733AS—designed and manufactured by the Radio Corporation of America.

Where Accuracy, Simplicity, Readability mean so much they choose . . .

Westinghouse Instruments

. . . *unfailing performance* and *co-ordinated space-saving design* . . . these, too, were instrument "musts" for the receiving tube test station manufactured by RCA.

Westinghouse Instruments easily met these requirements. The result . . . an exact, diverse and rapid control over the quality of all modern types of receiving tubes.

What Are YOUR Electrical Measuring Problems?

Would they include . . . reliable performance? . . . styling? . . . size? . . . readability? . . . or different types of service? . . . portable? . . . switchboard? . . . panel? . . . recording?

The completeness of the Westinghouse line of electrical measuring instruments will answer your special or ordinary problems. Every Westinghouse Instrument is backed by more than 60 years of skill and experience in every field of industry. J-40366

Westinghouse Instruments Also Provide You With . . .

- Dials that stay white under all conditions
- Magnets that stay permanent
- Pivots with high shock capacity and low friction
- Springs that remain constant for life
- Quick delivery of more different ratings and types
- Complete nationwide service

Westinghouse Instrument Specialists are available in the field for consultation on your instrument problems. Call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Send for Booklet B-2209-A, Communication Instrument Booklet B-3283, or Switchboard Instrument Booklet B-3363.

Westinghouse
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electrical Measuring Instruments for ANY Job

TAKING A BALL BEARING'S PULSE

A pre-production physical such as this is one Federal way of anticipating bearing fatigue long before a ball bearing takes on an anti-friction assignment. How will this or that type bearing take pre-determined thrust loads...radial loads...overloads? At what speeds and with what temperature effects? Any changes in quiet-running qualities? These are the advance forecasts of Federal Bearings' performance, simulating *your* operating conditions on our specially designed proving grounds.

Full-time operators are assigned to batteries of similar machines for daily checks on every type and size Federal Bearing out of regular production. The test results gathered are production data, too—a follow-up on over 100 preceding manufacturing, inspection and cleaning operations that go into every Federal Bearing—continuing evidence that, with *every fourth operator an inspector*, Federal Bearings are "ready" for any service requirement. And it's your assurance that Federals have the right degree of resilience and resistance to compression and distortion... with no sacrifice of precision.

Specify Federal Ball Bearings for the heavy loads—in any range or size. Write for catalog "K."

THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

REPRESENTATIVES LOCATED AT
2640 Book Tower, Detroit 26, Mich.
402 Swetland Bldg., Cleveland 15, Ohio
8 South Michigan Avenue, Chicago 3, Ill.

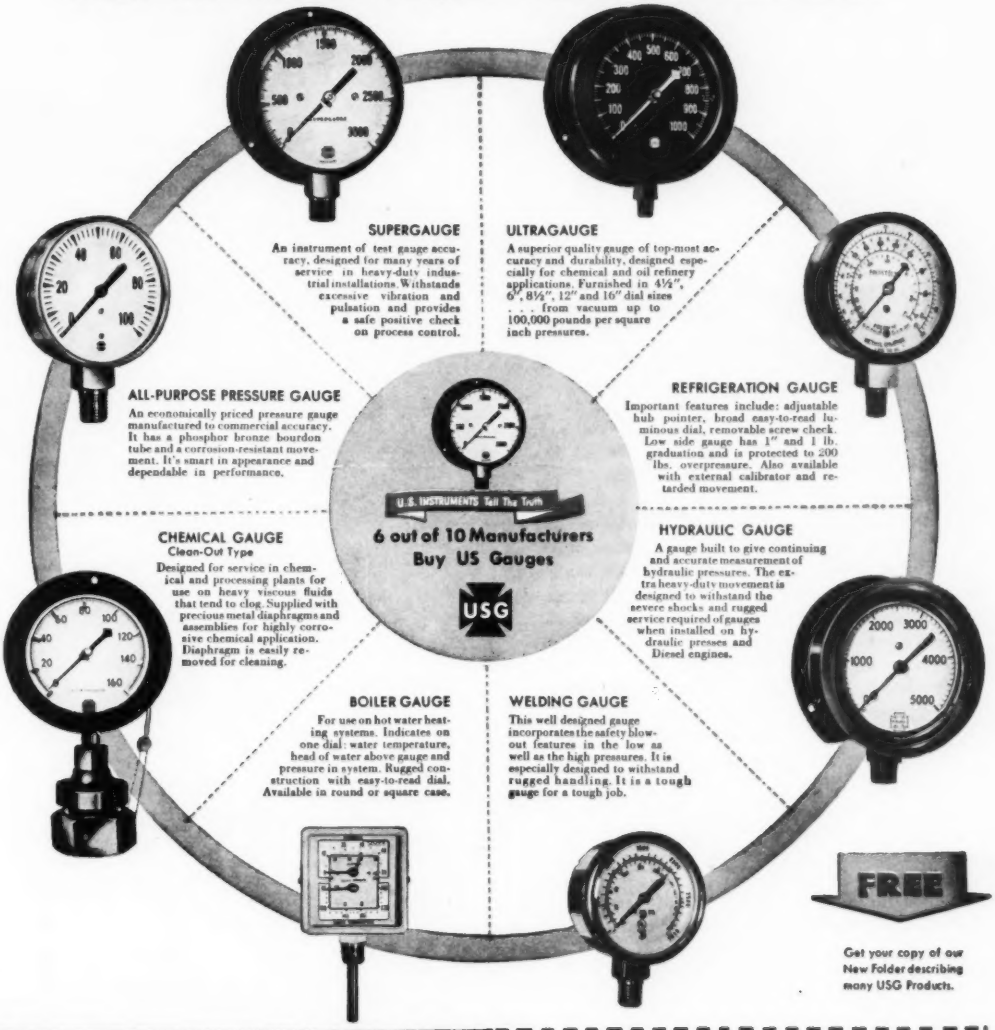
Quality since 1908

FEDERAL BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

USG HELPS YOU SELECT GAUGES

From the World's Largest Family of Instruments



SUPERGAUGE
An instrument of test gauge accuracy, designed for many years of service in heavy-duty industrial installations. Withstands excessive vibration and pulsation and provides a safe positive check on process control.

ULTRAGAUGE
A superior quality gauge of top-most accuracy and durability, designed especially for chemical and oil refinery applications. Furnished in 4½", 6", 8½", 12" and 16" dial sizes . . . from vacuum up to 100,000 pounds per square inch pressures.

ALL-PURPOSE PRESSURE GAUGE
An economically priced pressure gauge manufactured to commercial accuracy. It has a phosphor bronze bourdon tube and a corrosion-resistant movement. It's smart in appearance and dependable in performance.

REFRIGERATION GAUGE
Important features include: adjustable hub pointer, broad easy-to-read luminous dial, removable screw check. Low side gauge has 1" and 1 lb. graduation and is protected to 200 lbs. overpressure. Also available with external calibrator and retarded movement.

U.S. INSTRUMENTS Tell The Truth

6 out of 10 Manufacturers Buy US Gauges

USG

CHEMICAL GAUGE
Clean-Out Type
Designed for service in chemical and processing plants for use on heavy viscous fluids that tend to clog. Supplied with precious metal diaphragms and assemblies for highly corrosive chemical application. Diaphragm is easily removed for cleaning.

HYDRAULIC GAUGE
A gauge built to give continuing and accurate measurement of hydraulic pressures. The extra heavy-duty movement is designed to withstand the severe shocks and rugged service required of gauges when installed on hydraulic presses and Diesel engines.

BOILER GAUGE
For use on hot water heating systems. Indicates on one dial: water temperature, head of water above gauge and pressure in system. Rugged construction with easy-to-read dial. Available in round or square case.

WELDING GAUGE
This well designed gauge incorporates the safety blow-out features in the low as well as the high pressures. It is especially designed to withstand rugged handling. It is a tough gauge for a tough job.

FREE

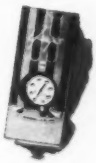
Get your copy of our New Folder describing many USG Products.

USG
UNITED STATES GAUGE

Clip and Mail This Coupon Today!

UNITED STATES GAUGE
DIVISION OF AMERICAN MACHINE AND METALS, INC.
SELLERSVILLE 24, PA.

Without obligation or cost please send me a copy of your new helpful folder.



Mr. _____ Title _____

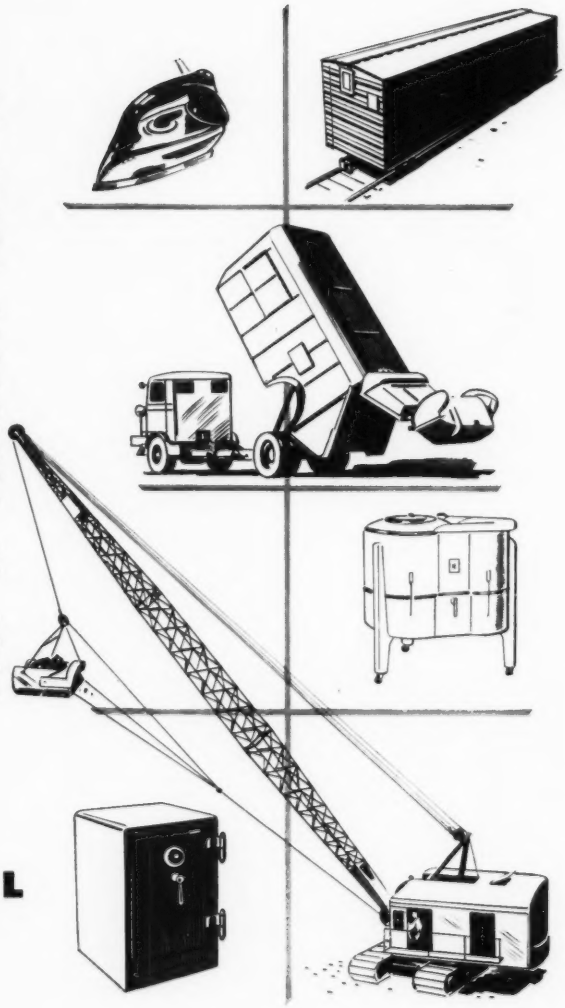
Company _____

Address _____

City _____ State _____

Mayari R

the versatile low-alloy high-tensile steel



Almost every industry that uses steel in its products or its equipment is employing Mayari R in some form or another.

It is used in freight cars and washing machines, in power shovels and outdoor movie screens, in ventilating equipment and truck bodies, in tractors and flat irons, in furnaces and fences, in beer kegs and oil tanks, to name a few.

The reasons for this widespread use are important. Mayari R is an economical grade of low-alloy, high-tensile steel with properties that allow a far wider range of design possibilities than do those of carbon steel.

Further, Mayari R is not difficult to fabricate. It can be cut, formed, punched and welded by ordinary methods in the average shop. Only slight allowances are needed to take care of its higher properties.

Mayari R is produced in hot- and cold-rolled sheets and strip, plates, bars, structural shapes, and cold-formed shapes.

Further information on this steel, its properties, and its many industrial applications may be found in Mayari R Catalog 209. Write or phone our nearest office for a copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

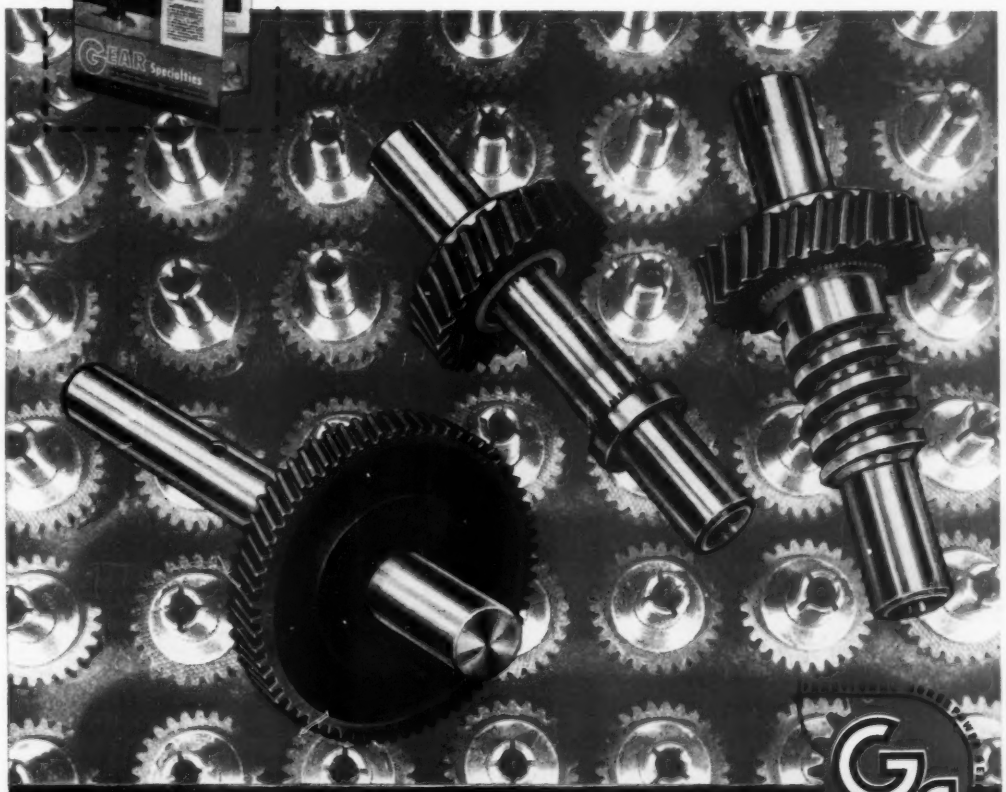
★ BETHLEHEM STEEL ★

SEND FOR THIS FREE CATALOG-BULLETIN

The G.S. Gear Bulletin illustrates and describes many different types and applications of G.S. Small Gears. It offers valuable aid to anyone concerned with specifying Gears 12 D.P. and finer. Write today!

ARE YOU PAYING *TOO MUCH* FOR SMALL GEARS?

FRACTIONAL Horsepower Gearing can be *very* costly! It isn't so much the money you pay for the gears. It is rather the high price you pay in lost customers and prestige when your gears are poor in quality and lack uniformity . . when your product fails to give long, smooth, dependable service! The mass production of fine, uniform, precision-cut Small Gearing is a *highly developed specialty* of ours. Year after year, many of America's largest and most particular buyers look to us for *all* of their Small Gear needs. G. S. products are modestly priced for the greater service and satisfaction they give. Ask our competent staff for ideas, suggestions, and estimates on *your* requirements . . write today. There's no obligation.



GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE · CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

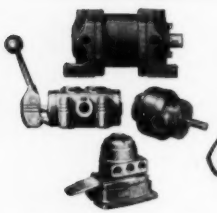
3 essentials

GEROTOR offers to help you apply the correct air and hydraulic devices to your equipment!

1

Engineer-Distributors at Your Service

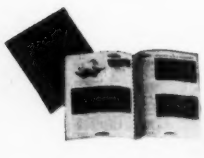
Gerotor service is featured by the engineering assistance of its factory trained distributors. These men are qualified from long experience to handle any air and hydraulic problem. Located in all principal cities, they can assist in laying out the circuit best suited to your operating requirements and recommend the correct equipment to provide long years of satisfactory operation.



2

The Complete GEROTOR Line

Gerotor can furnish the exact model valve, cylinder and pump to meet individual requirements. For example—Gerotor 4-Way Hydraulic Valves are offered in 50 models with 4 types of action—standard, spring return, spring centered and ball detent; 5 piston designs; 6 types of operation—hand, foot, cam, solenoid, oil and air pressures; 7 sizes—$\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$, $1\frac{1}{4}''$ and $1\frac{1}{2}''$.



3

Informative Literature

The 100-page Gerotor Catalog describes every detail of hydraulic and air valves, cylinders, pumps, pump units. It represents the most thorough presentation of hydraulic and air devices that long experience in this field can prepare. If you do not have the new Gerotor Catalog in your file for reference and assistance, write for your copy today.

GEROTOR MAY CORPORATION
Dept. PE 1, Baltimore 3, Maryland

WHEN YOU APPLY HYDRAULIC OR AIR POWER *Plan with* **GEROTOR**

Team up with HYATTS for improved design

IT'S not uncommon to find Hyatt Roller Bearings outlasting the machines and equipment for which they were selected.

For when better bearings like Hyatts are teamed up with better product design exceptional performance is to be expected.

With so many sizes and types of Hyatts to choose from—and with our many years of application experience at your service—we believe we can help you to keep your products always ahead of the procession, if given the opportunity to demonstrate. Put your problem up to the nearest Hyatt office. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Chicago, Detroit, Pittsburgh and Oakland, Calif.

HYATT ROLLER BEARINGS

enclosed gear drives...

for every industrial need!

Foote Bros. Hypower Worm Gear Drives, both horizontal and vertical types, offer new economies in space, weight and cost. Increased load-carrying capacity is accomplished by a revolutionary technique in generating gears. The oil bath is cooled by passing a high velocity stream of air through an air channel cylinder immersed in the bath. This provides greatly increased thermal capacity.

Foote Bros. Hygrade Worm Gear Drives are available in a wide variety of types. This line is newly designed and includes sizes and ratios to meet practically any requirement.

Foote Bros. Maxi-Power Helical Gear Drives are available in single, double and triple reductions. This newly developed line assures maximum performance made possible by the latest in engineering development and by improved methods in manufacture.

Regardless of what your requirements in gears or enclosed gear drives may be, call on Foote Bros. There is a sales office or representative near you.

MAXI-POWER ENCLOSED HELICAL GEAR DRIVES

HYGRADE ENCLOSED WORM GEAR DRIVES

HYPOWER ENCLOSED WORM GEAR DRIVES

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

Dept. W, 4545 South Western Boulevard • Chicago 9 Illinois

Foote Bros. Gear and Machine Corporation
Dept. W, 4545 S. Western Blvd., Chicago 9, Ill.

Please send me bulletins or information on

- ☐ Hypower Enclosed Worm Gear Drives
- ☐ Hygrade Enclosed Worm Gear Drives
- ☐ Maxi-Power Enclosed Helical Gear Drives

Name .....

Company .....

Address .....

City ..... *State* .....

CONTROLLED COMPRESSIBILITY

Armstrong's Cork-and-Rubber Compositions are designed especially for applications where certain properties of the various synthetic or natural rubbers are required but where their normal side flow is objec-

DATA ON SEALING MATERIAL

NO. SC-167 CORK-AND-SYNTHETIC-RUBBER COMPOSITION

Seal for watt-hour meter—Soft enough to take up the irregularities of glass cover and die-cast meter base; withstands abrasion caused by turning cover into usual attachment slots; treated to reduce surface friction.

TYPICAL APPLICATIONS

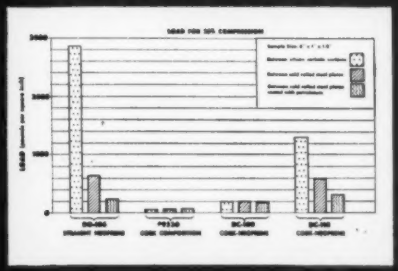
FACTORS IN CHOOSING RESILIENT GASKETS

Once a good flange or joint design has been developed, there remains the problem of choosing a specific gasket material. A review of principal factors can help narrow the range of possible choices and speed final selection.

TEMPERATURE. Constant temperatures in excess of 250° F. damage most resilient materials. Under certain conditions, however, some resilient materials may be used where temperatures exceed this limit. When temperatures fluctuate, for example, an average figure may be used as the upper limit. We suggest, therefore, that you check application details with us before you abandon the possibility of using a resilient gasket on account of temperature.

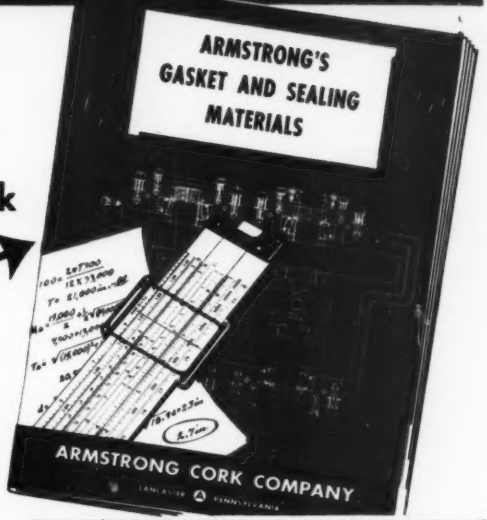
INTERNAL PRESSURE. When internal pressures are high, a tough, non-porous material should be used. Gaskets normally should be as thin as flange surfaces will permit. Special groove or flange design may be required.

10 TYPICAL DISCUSSIONS



USEFUL CHARTS

Send For Your Copy Of This Gasket Handbook



This booklet contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber-sheet sealing materials. It suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also gives materials charts, typical applications, and late government specifications.

For your free copy, fill in coupon and mail to Gaskets and Packings Department.

Armstrong Cork Co. Gaskets and Packings Dept.
7101 Arch Street, Lancaster, Pennsylvania

Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

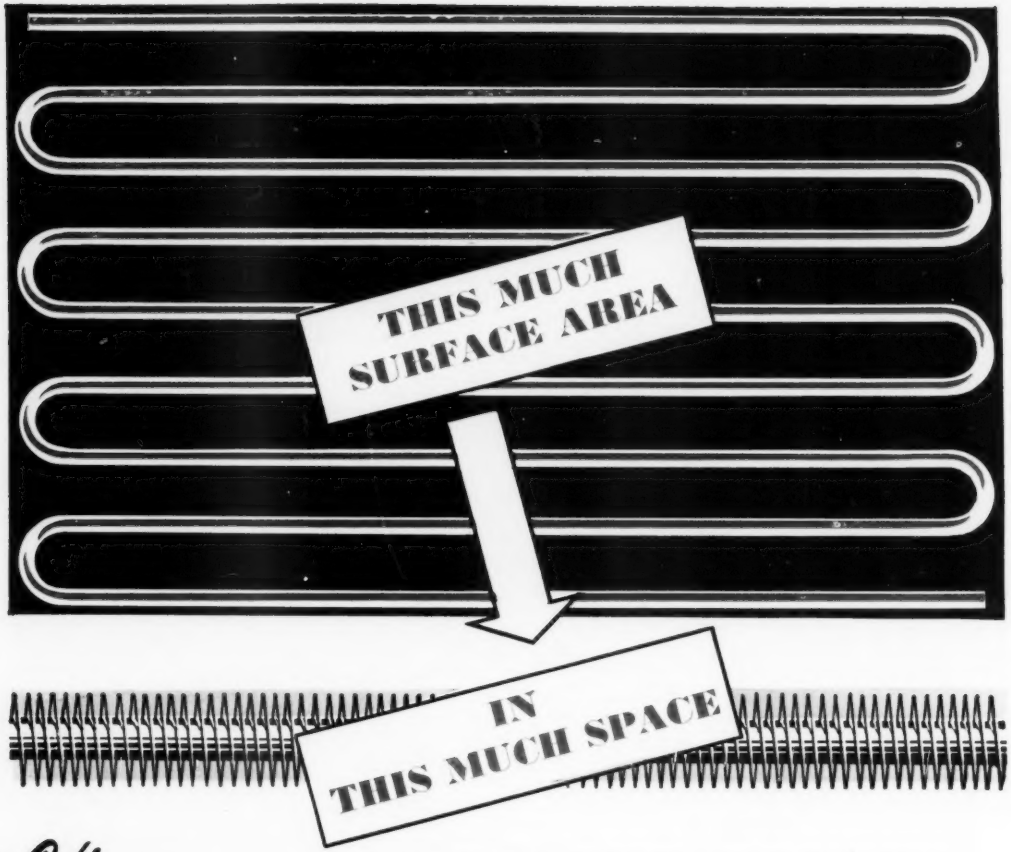
NAME _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

ARMSTRONG'S
GASKETS • PACKINGS • SEALS



When you use WOLVERINE TRUFIN

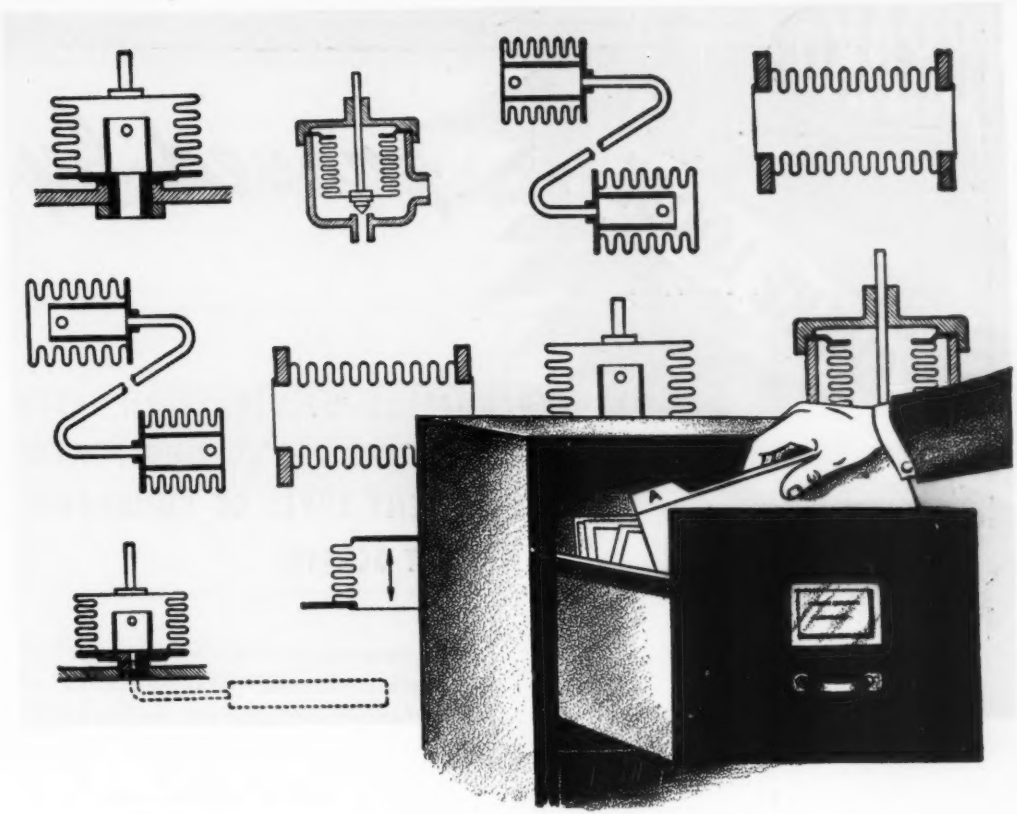
. . . . the integral finned tube

You can pack a lot of heat exchange efficiency in a small space when you use Trufin instead of plain tubing. That means that any product using tube for heat transfer can be built in much more compact space and still retain fullest efficiency.

Being integral with the tube itself, the fins will withstand vibration and extreme temperature changes. Trufin is available in a variety of diameters, alloys, fin heights and spacings.

Send for folder giving full information.

WOLVERINE TUBE DIVISION
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
INCORPORATED
MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING
1415 CENTRAL AVENUE • DETROIT 9, MICHIGAN



The answer to your design problem may be already in our files!

If it involves temperatures or pressures, chances are Fulton Sylphon or Bridgeport Thermostat has the answer "on file". We've specialized in this field for years—have developed bellows assemblies and bellows devices used throughout industry. One of these ready-to-use designs may fit your product or your product improvement plans perfectly.

But we don't stop there. If your requirements call for a special type, our engineers will work with you—develop a bellows assembly or device *specifically adapted* to your needs.

Complete production facilities for large volume orders, plus finest quality materials and workmanship, assure satisfaction. Write today for Catalog **AB-1200** that gives you the whole story.

FIRST WITH BELLOWS

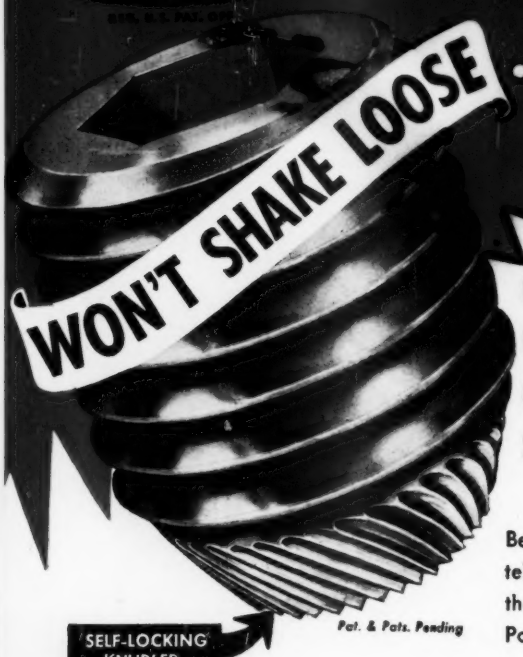
Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON
DIVISION

ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

UNBRAKO



... proved by

EXPLANATION OF VIBRATION TESTS DEMONSTRATING THE HOLDING POWERS OF DIFFERENT TYPES OF "UNBRAKO" SOCKET SET SCREWS

Better than words, the graph of actual vibration tests quickly tells the story of the exceptional "HOLDING POWER" of the "Unbrako" Self-Locking Set Screw with the Knurled Cup Point . . . *"the screw that won't shake loose."*

Vertically, the graph is divided into increments of 30 minutes. Each bar—black for Plain Cup Point and red for Knurled Cup Point—represents a screw tested and the number of minutes at which it loosened. *The height of each black bar, therefore, is a direct measure of the length of time before the plain pointed screw shook loose.* The Self-Locking Knurled Cup Pointed Screws—indicated by the red bars—were still tight at 300 minutes.

All screws were tested under identical conditions. Rate of vibration—1750 cycles per minute . . . duration of test—until screw shook loose or tests were discontinued.

Analyzing the graph and comparing the two types of screws, we find that the most favorable test of the Plain Cup Point shows a failure at 10 minutes and 40 seconds. *No Knurled Cup Point shows signs of loosening at 300 minutes—more than 28 times the "HOLDING POWER" of the Plain Cup Point—a tremendous superiority . . . as proven by actual tests and use.*

The "Unbrako" Self-Locking Set Screws with the Knurled Cup Point can be used over and over again.

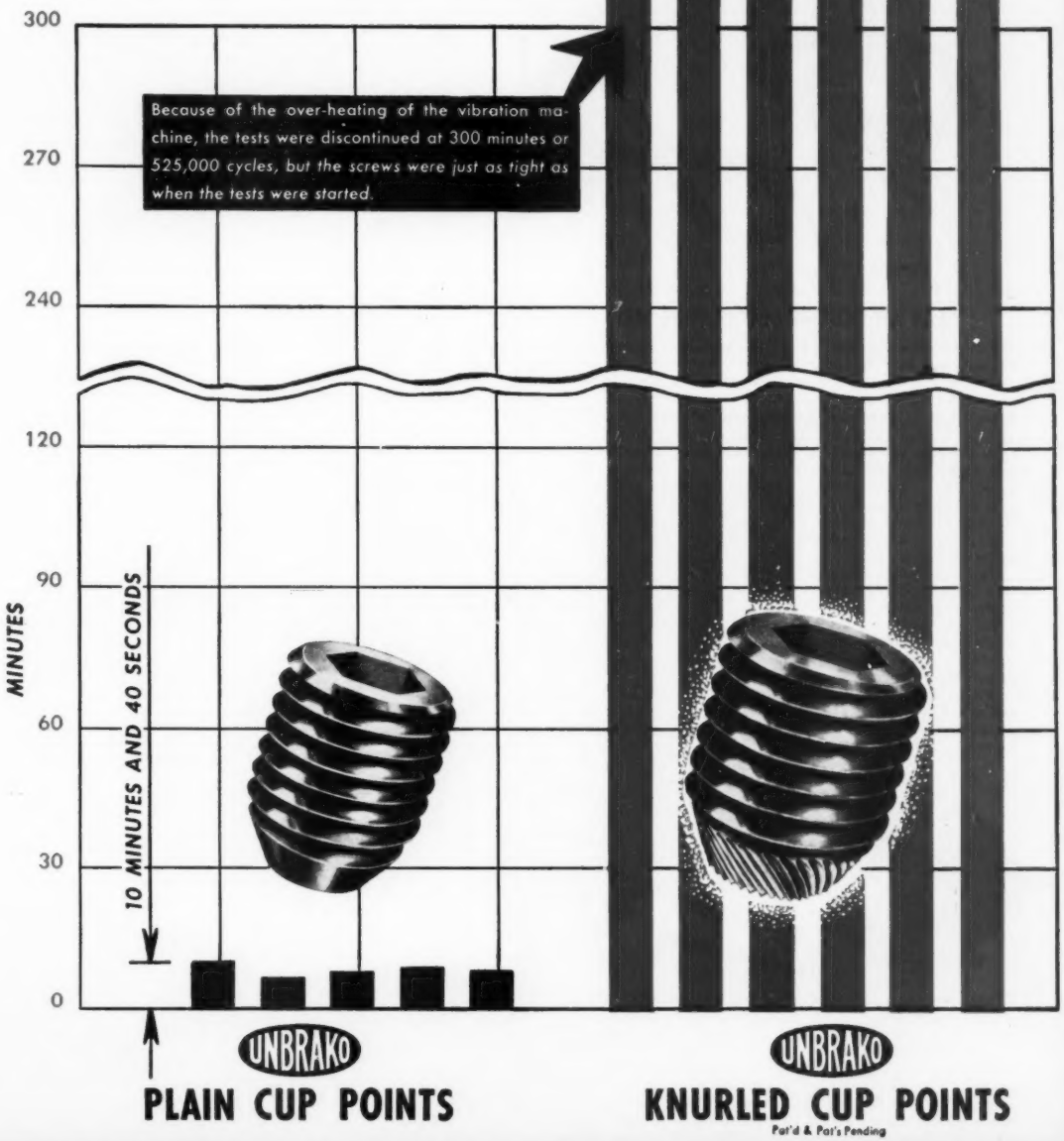
OVER 45 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

BOX 545, JENKINTOWN, PENNSYLVANIA

BRANCHES: CHICAGO DETROIT ST. LOUIS SAN FRANCISCO

actual tests



Wiring Components FOR PRODUCT DESIGN

CAN YOU USE THIS COST-CUTTING SERVICE?

Here's a service designed to cut your assembly time and increase your selling story. It's the General Electric Flamenol* cord set service—a service designed to cut product assembly time to an absolute minimum.

Here's what we did for one manufacturer: In addition to the standard molded-on plug, and cord with stripped and twisted ends, we included both a switch and a socket. (This time-saving assembly is shown at left, above.) If you produce your product in volume, you'll be interested in this General Electric service. But . . .

If you have no assembly problems, you can order standard General Electric Flamenol cord sets in ready-cut lengths of 6, 8, and 11 feet. They make work easy because ends are stripped and twisted for easy connection. And . . .

They are visible evidence of high quality on any product. That's why General Electric Flamenol cord sets are boosting sales of cord-equipped products all over the country.

Flamenol cord sets have a strong, molded-on plug that keeps the double-strength prongs straight and true. The smooth, thermoplastic insulation cleans in a jiffy with a quick wipe and won't fray, kink or pull loose from the plug.

We've made millions of them for use on clocks, lamps, fans, radios and a host of other light-duty appliances, so why not take advantage of our experience? Just tell us what you want, and we'll tell you what we can do. Check box A below.

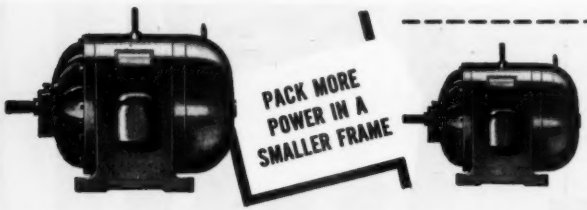
CORDS BUILT TO TAKE TOUGH TREATMENT

That's a built-in feature of every General Electric portable cord—ability to take the same tough treatment you've designed into your product.

For example, Type ST Flamenol heavy-duty portable cords are designed to give long term, dependable service under severe operating conditions. They are flexible, light in weight, easy to handle and mechanically tough and strong. The thermoplastic jacket is resistant to water, oils, alkalies, sunlight and acids. Type ST cords are recommended for use on portable tools in industrial plants, mines, garages, packing houses, and similar tough-duty locations.

Perhaps your product does not require a cord built to meet such heavy duty requirements. But whatever your requirement—from light-duty appliance to heaviest tool—there is a General Electric portable cord to supply power to it.

Do you have a power cord problem—would you like to know more about General Electric portable cords? Just check C in the coupon.



Today's emphasis on greater power output from smaller motor frames makes magnet wire selection more important than ever before. That's why it's a wise designer who investigates the many features of General Electric Deltabeston* magnet wire before writing his specs.

Deltabeston magnet wire can take overload temperatures as high as 200 C. The purified-asbestos insulation is firmly bonded to the conductor with a special heat-resisting adhesive and by an exclusive process. This tough, flexible insulation, plus the extreme softness of the copper, permits the use of Deltabeston for the most intricate winding applications.

But get the whole story. We've prepared it in an interesting booklet that includes a handy table to simplify selection. If you'd like a free copy, just check B in the coupon below.

General Electric Company (Section L3-167)
Construction Materials Department
Bridgeport 2, Connecticut

Please send me, free, the items checked below:

A ☐ General Electric Flamenol cord set service
B ☐ Deltabeston Magnet Wire Booklet
C ☐ Information on General Electric portable cords
D ☐ Information on the subject attached

Name _____

Company _____ Title _____

Street _____

City _____ Zone _____ State _____

GENERAL ELECTRIC

Trade-mark Reg. U. S. Pat. Off.

WHY WELD, CLINCH OR STAKE NUTS?

JUST SNAP IN *Speed Grips**

Now you can attach square nuts to metal parts *by hand!* Just thumb pressure snaps the *new* SPEED GRIP Nut Retainers in place. SPEED GRIPS, like many SPEED NUTS, have spring steel "mechanical hands" that lock them in bolt-receiving position. They are ideal for blind assembly attachments because SPEED GRIPS do not have to be held with a wrench.

Developed as a companion item to the famous Tinnerman SPEED NUTS, the SPEED GRIP Nut Retainer gives all the self-retaining advantages of SPEED NUTS in applications requiring square nut attachments.

Write for the details on this latest Tinnerman development. The savings it can make in equipment investment in assembly steps, in material handling and in parts costs will surprise you. And ask your Tinnerman representative about our Fastening Analysis Service. Tinnerman Products, Inc., Cleveland 13, Ohio.

In Canada: Dominion Fasteners Limited, Hamilton
In England: Simmonds Aerocessories, Ltd., Treforest
In France: Aerocessoires Simmonds, S. A., Paris

New Tinnerman SPEED GRIPS are available in a complete range of sizes. Screw size and panel range are stamped on each fastener.

Here's how SPEED GRIPS can be applied to panels on the moving assembly line. In a few seconds, assembler can snap in self-aligning SPEED GRIPS . . . no extra handling . . . no special equipment required!

TINNERMAN *Speed Nuts*

MORE THAN 4000 SHAPES AND SIZES

The New General Plate Laminated Silver on Aluminum Button

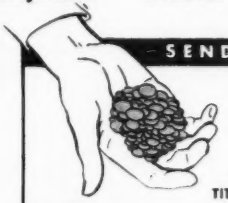
SILVER DOME Provides High Electrical Conductivity

ALUMINUM BASE Reduces Weight, Has Greater Heat Dissipation, Reduces Bouncing

Again General Plate pioneers in laminated metals . . . this time it is the new *Silver on Aluminum* Button...especially suited for heavy-duty contacts or large contacts. The silver surface gives better electrical performance. The aluminum makes the contact lighter-in-weight, permits larger contacts because it has high heat dissipation characteristics.

General Plate *Silver on Aluminum Buttons* reduce costs, too, because they replace expensive solid silver contacts. Moreover, all requirements can be met with these money-saving contacts. They are available in practically all regular laminated button shapes. Write for information and samples.

GENERAL PLATE DIVISION
of Metals and Controls Corporation
101 Forest Street, Attleboro, Mass.



SEND FOR SAMPLES TODAY

GENERAL PLATE DIVISION
of Metals and Controls Corporation
101 FOREST STREET, ATTLEBORO, MASS.

Gentlemen: Please send me complete information and samples of Silver on Aluminum Buttons.

NAME_____

TITLE_____

FIRM_____

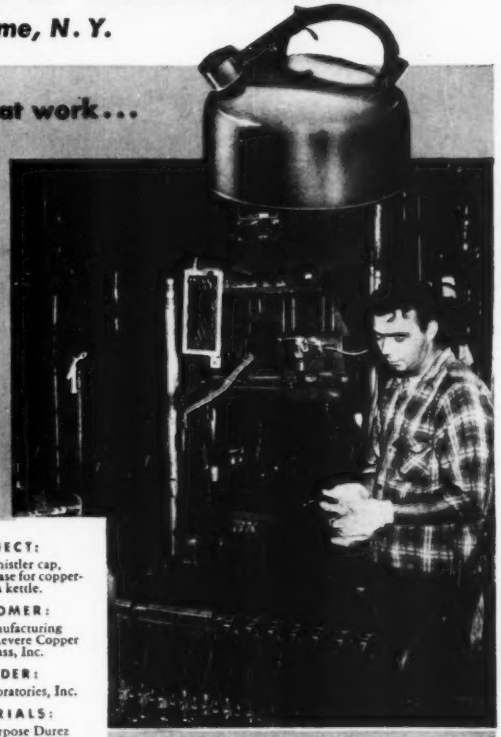
ADDRESS_____

I-149

It pays to use your custom molder's know-how

Say the Revere Men in Rome, N. Y.

No. 1 in a series on Plastics Skill at work...



PROJECT:
Handle, whistler cap, and finger release for copper-clad tea kettle.

CUSTOMER:
Rome Manufacturing Division of Revere Copper and Brass, Inc.

MOLDER:
Norton Laboratories, Inc.

MATERIALS:
General purpose Durez phenolic in handle, steam-resistant Durez in cap, polyamide trigger.

PRECISION PLANNING improves plastic parts design. Norton development engineer uses vernier height gauge to position front assembly hole on customer's model in perfecting new handle.

CREATIVE ENGINEERING speeds output, lowers cost. Duplex ram plunger press remodeled by molder cuts cure time. Shrink fixture in foreground assures accurate assembly, prevents waste.

● Next time your plans suggest consideration of plastics, why not call in your custom molder early — when he can serve you to best effect?

Example: Tools of a good housekeeper's "dream kitchen", a new line of Copper-Clad Stainless Steel Revere Ware shows the value of having experienced plastics molders cooperate in product development.

With a good idea ready for the final touches, Revere officials called in Norton engineers. Special skill in custom molding enabled Norton to make constructive design suggestions for product betterment. Then, they devised special production equipment that multiplies output several-fold and assures precision fit in assembly.

Durez phenolics, impervious to boiling water, light weight, and of lustrous, heat-resistant finish, provide desired qualities in the handle and cap.

As specialists in the phenolics since the industry's earliest days, Durez field engineers, too, can bring the authority of experience to your problems.

At any stage in your product plans, from the basic idea onward, we will welcome your invitation to assist.

A new hit with plastics users everywhere is the handy "Durez Clock-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 131 Walck Rd., N. Tonawanda, N. Y.

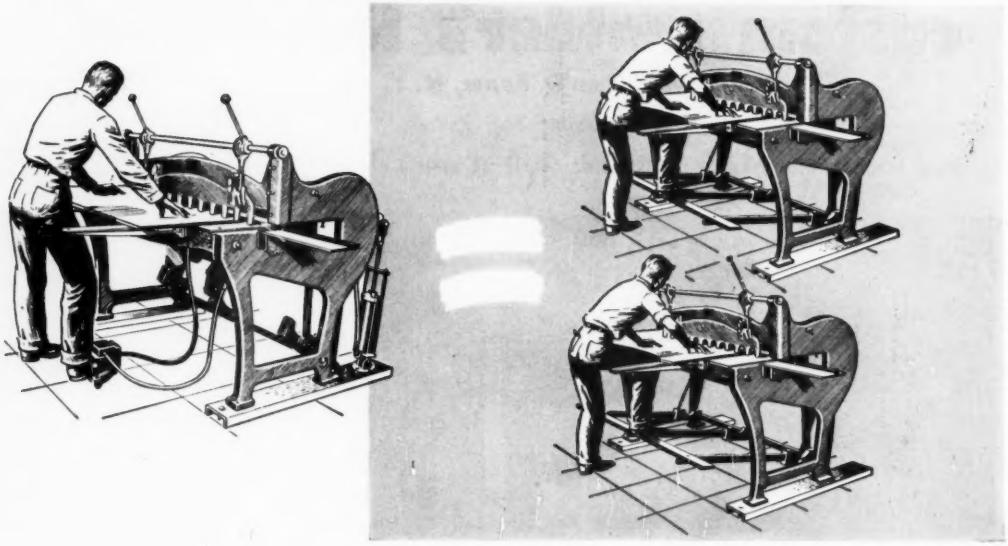
DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

Make ONE machine do the work of TWO



Airpower your manually operated shears, power presses and other machines with SCHRADER Pneumatic Machine Controls

Yes, it's a fact that with Schrader Controls operators work more efficiently, with greater safety, and less fatigue.

Take a shear, for example. Ordinarily foot operation is awkward and tiring. And when the strips to be sheared are long, two men are needed to position the material and operate the shear.

What a difference with Schrader Pneumatic Controls! One man does the whole job easily . . . at the mere touch of a foot pedal. Moreover, the foot pedal can be shifted at will to any position desirable for the comfort and convenience of the operator. With Schrader Controls the same machine will do more work per hour . . . and will also shear heavier gauge metals.

Write today for the NEW folder describing Schrader Pneumatic Controls (use coupon below) . . . And remember, our engineers can devise Schrader Controls for almost any machine operation in your plant.

FREE

Get your copy of this information-packed 8 page Booklet describing Schrader Air Control Products.

Schrader
PRODUCTS
CONTROL THE AIR

A. SCHRADER'S SON, 496 Vanderbilt Avenue
Brooklyn 17, N. Y.
Division of Scovill Manufacturing Company, Incorporated

Please send me your FREE BULLETIN and more information about the products I have checked in circles below.

Name_____

Company_____

Address_____

City_____ State_____

- ○ *Air Cylinders*
- ○ *Air Valves*
- ○ *Press Controls*
- ○ *Air Ejection Sets*
- ○ *Blow Guns*
- ○ *Air Hose & Fittings*
- ○ *Hose Reels*
- ○ *Hydraulic Gauges*
- ○ *Air Pressure Regulators*
- ○ *Air Line Couplers*

WE'D RATHER LOSE AN ORDER THAN RUN A BLUFF
Perhaps our conservative attitude towards metal powder applications has discouraged many manufacturers from making use of powder metallurgy.
Naturally, we're sorry about this. But our established realistic policy of taking only the kind of business that results in lasting satisfaction for the customer remains unchanged.
We'd still rather lose an order than speculate with a manufacturer's time and money on the mere chance that powder metallurgy might work for him.
That's why we consistently emphasize the requirements for practical metal powder parts production. That's why we tell you that we can't honestly begin to accept your business unless the parts you need fulfill these conditions: (1) The shape permits good die fill and proper density; (2) the order is sufficiently large to justify initial tooling costs; (3) the physical properties and tolerances required are within the range obtainable in normal factory production.
MORAINE PRODUCTS
DIVISION OF GENERAL MOTORS DAYTON, OHIO
METAL POWDER PARTS . . . BY MORAINE

Reynolds weaves
WIRE CLOTH EXACTLY TO YOUR SPECIFICATIONS
• Yes, your product *is* different. The wire cloth you put into your product must meet its special needs. You want cloth that is different from "standard." Then write your own specifications—Reynolds will weave it accordingly. Specify the metal or alloy, as well as the diameter of the wire—temper, workability and flexibility will be *right!* Weave and mesh of the cloth, and finish, too—all exactly as ordered. Reynolds knows how—from 53 years' experience. If you want your industrial wire cloth "tailor made," send your specifications to Reynolds engineers, metallurgists and weaving experts . . . an inquiry neither costs nor obligates you.
Reynolds
Industrial
WIRE
CLOTH
REYNOLDS WIRE CO., DIXON, ILLINOIS

WE WOULD LIKE TO POINT OUT

underfilm corrosion just *Can't* happen with

Weirzin

ELECTROLYTIC ZINC-COATED SHEETS AND STRIP

Paints, enamels, lacquers, varnishes and lithographic inks adhere to bonderized Weirzin securely and permanently, because underfilm corrosion cannot occur. The tight, malleable zinc coating, electrolytically applied, becomes an integral part of the sheet or strip... remains intact under all conditions of temperature and humidity . . . provides a perfect "tooth" for spray, dip or roller applications.

Extensive fabrication does not weaken this bond—after deep-drawing, forming and punching, the zinc coating remains unruptured and evenly deposited. There are appreciable savings in manufacturing, too, because Weirzin sheets and coils require no pickling or buffing, and very little cleaning . . . there is no need for a primer under paint.

WEIRTON STEEL CO.

WEIRTON STEEL COMPANY

WEIRTON, W. VA., *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION,** *Executive Offices, Pittsburgh, Pennsylvania*

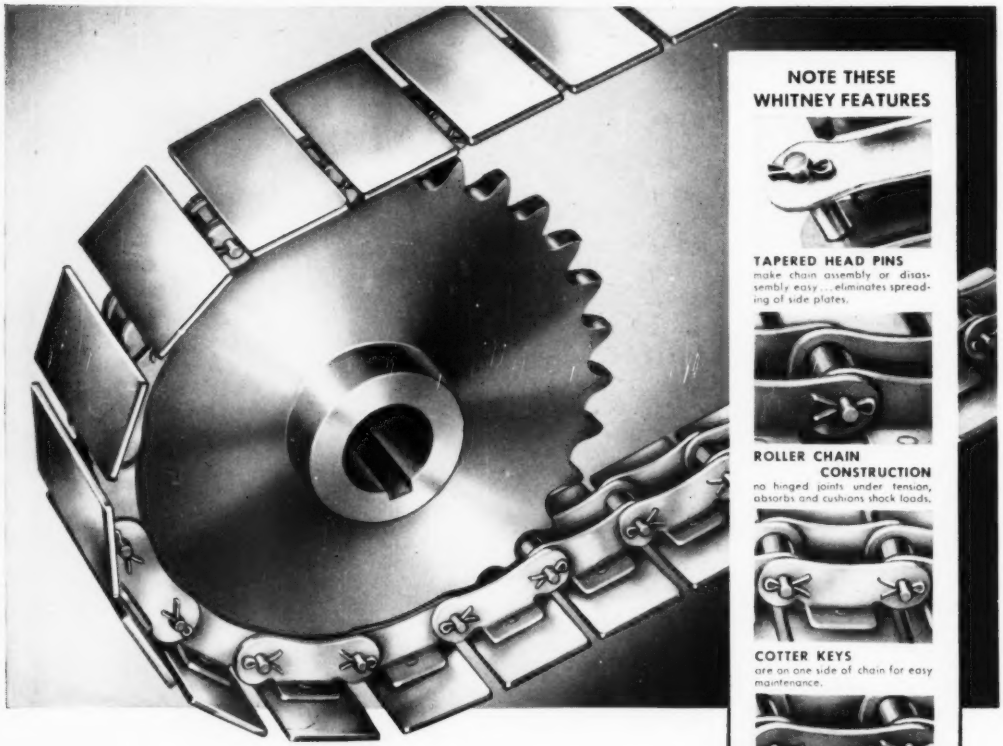
NATIONAL STEEL

Announcing

THE NEW WHITNEY

Platform Conveyor Chain

For Unit Conveying of Bottles, Cans, Small Package Goods



NOTE THESE WHITNEY FEATURES

TAPERED HEAD PINS
make chain assembly or disassembly easy . . eliminates spreading of side plates.

ROLLER CHAIN CONSTRUCTION
no hinged joints under tension, absorbs and cushions shock loads.

COTTER KEYS
are on one side of chain for easy maintenance.

ALL WELDED CONSTRUCTION
elimination of rivets makes it easy to keep chain clean. Assures level top plates.

NEW BEVELED EDGE
top plates have new edges for smooth, sure transfer from one conveyor to another.

Again Whitney leads in chain design with the new Platform Conveyor Chain! This new construction assures smooth, steady travel for all types of bottle and package materials, regardless of length or speed of conveyor line. It will help you to maintain production by reducing traffic jams, spillage and breakage.

Whitney Platform Conveyor Chain is manufactured in various widths and materials of platform plates, covering all requirements of conveying.

Whitney Silent and Roller Chains, plus Cut Tooth Sprockets . . . the all steel drives . . . simplify your power transmission designs. Specify Whitney for dependable, smooth operation and long life. Write for information.

WHITNEY CHAIN & MFG. CO.

Division of Whitney-Hanson Industries, Inc.

204 HAMILTON STREET, HARTFORD 2, CONN.

ONLY PHILLIPS RECESSED HEAD SCREWS

27
PHILLIPS MANUFACTURERS HAVE FACILITIES FOR PRODUCING MANY MILLIONS OF PHILLIPS SCREWS PER 8-HOUR DAY
Remember, unlimited production potential is one of the basic essentials you can't afford to overlook in choosing a cross recessed head screw. With Phillips Screws, you can depend on it.

are available from MULTIPLE sources of supply

With the cross recessed head screw rapidly becoming the preferred screw for all types of industrial assemblies, it is all-important to be sure that present and future needs can be supplied.

Since Phillips is the only cross recessed head screw with *multiple* sources of supply, Phillips Screws are your logical choice. And this is just one of the five important reasons why *only* Phillips Screws give you *all* the advantages of the cross recess design.

Get this new Fact-Full Booklet

that lets you in on the important facts you can't afford to overlook when you choose cross recessed head screws. It's FREE. Use the coupon.

GET ALL THE ADVANTAGES OF ASSEMBLY WITH CROSS RECESSED HEAD SCREWS...

GET PHILLIPS Recessed Head SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

27 SOURCES

American Screw Co.
Camcar Products Co.
Central Screw Co.
Continental Screw Co.
Corbin Screw Div. of American Hdwr. Corp.
Elco Tool & Screw Corp.
The H. M. Harper Co.
Lamson & Sessions Co.
Milford Rivet and Machine Co.
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Pheoll Manufacturing Co.
Reading Screw Co.
Rockford Screw Products Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Seaboard Screw Corp.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wales-Beech Corp.
Wolverine Bolt Company

Phillips Screw Mfrs.,
c/o Horton-Noyes Co.
1800 Industrial Trust Bldg.
Providence, R. I.

PE-37

Send me the new booklet—"How to Select Recessed Head Screws for Practical Production Driving".

Name _____

Company _____

Address _____

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by Bridgeport Brass Co. "Bridgeport" BRASS CO. *Headquarters for BRASS, BRONZE and COPPER*

Metal Fabricating Outlook for 1949

Offsetting Higher Manufacturing Costs

What metal problems will confront users of copper and brass mill products in 1949? What will be the effects of high labor costs, tightness of supplies and high prices of raw materials? Answers to some of these questions can probably be drawn from our experiences during 1948.

In an effort to maintain prices of fabricated items, in spite of rising labor costs, raw materials and supplies, fabricators are making a careful study of the many factors involved and have taken one or more of the following steps where possible:

1. Cutting down the number of operations.
2. Reducing finishing costs; extra operations; bad work.
3. Increasing operating speeds.
4. Changing type of operations to reduce finishing costs.
5. Installing more modern, labor-saving equipment.
6. Better work flow and materials handling.
7. Redesigning of product for greater simplification.
8. Reducing maintenance through better materials.

Cutting Down Number of Operations

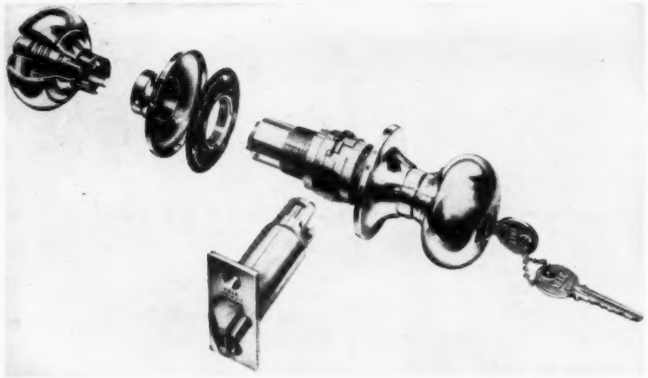
Because brass and other copper-base alloys are much more ductile than those made years ago, it is often possible to increase the severity of drawing operations between anneals, thereby cutting down the number of operations.

Reducing Polishing Costs and Spoiled Work

More attention is paid to finishing costs which involve a large percentage of labor. Careful control of annealing to produce small grain sizes and smoother metal cuts down polishing time. Much can also be done through more careful handling of both raw materials and the product itself during various stages of manufacture. Dents and scratches are expensive to remove and add much to costs and spoilage. Avoidance of tote boxes by battery grouping of operations, specially-designed trays for keeping polished work from denting, good housekeeping, respect for clean, fine surfaces all are helpful measures. Constant watching of excessive scrap and frequent analyses of costs involving expensive "extra operations" bring in unexpected dividends.

Cutting Costs and Improving Quality Through Redesign of Product

Redesign has played an important part in the builders' hardware field to bring down both cost of manufacture and installation by the consumer. For example, large, heavy front door locks with cast brass handles and escutcheon plates are rapidly being replaced by a smaller, lighter but much more efficient product. Door knobs and escutcheons are made from sheet brass by stamping or forming. The new locks are also more ingenious. The lock body is cylindrical in shape, requiring only two drilled holes in the door for rapid and inexpensive installation. Compare this to the old fashioned front door lock, which requires a large mortise by a skilled carpenter. The cost of installation was often higher than the price of the lock itself! Redesign of the product is, of course, helping other industries to increase sales appeal and often to reduce cost of manufacture.



Redesigned for modern styling and economical installation, the new Yale heavy-duty tubular lock is packed in pre-installation units. Double thickness of strip brass in the door knob prevents denting. Streamlined wrought brass escutcheons have replaced castings. Courtesy Yale & Towne Manufacturing Company, Stamford, Connecticut.

Increasing Operating Speeds

Many manufacturers have succeeded in speeding up their machining operations by changing to a free-machinable alloy. For example, the use of leaded Naval Brass instead of regular non-leaded Naval may double machinability without greatly affecting the strength or corrosion-resistant properties. Longer tool life and faster cutting speeds for tough alloys can often be attained by using the correct tool shape, a change to carbide or other harder tool materials, or by using the proper lubricants or coolants, which quickly draw away the heat generated by the cutting operation. Our laboratory has helped customers greatly in this respect.

Change in Operations to Reduce Finishing Costs

Change in methods of fabrication of the product may bring appreciable economies. One manufacturer, tired of the excessive cost of polishing rough sand castings of brass, redesigned the part by using a number of screw machine parts made from free-turning brass rod, which could be polished on automatic equipment. Another evolved a method of making a part from tubing by cold forging without changing the physical appearance of the finished part appreciably. This item had been made from sand cast brass for many years.

Changes from castings to hot and cold forgings have also taken place. Aside from lower finishing costs, a better article is often made from wrought metal as against a casting, doing away with the problem of poor castings, porosity, and rough surfaces.

Better Work Flow and Materials Handling

Rearrangement of machines and equipment to eliminate awkward handling; integrating departments to avoid unnecessary transportation from one room to another; more liberal use of modern conveyor systems and methods will increase production and cut labor costs. In fact, any speed-up of scheduling which will reduce the time of fabrication will bring savings resulting from more rapid turnover of investment.

(Continued on next page)

1948 Index in Preparation

Get your copy of the Annual Index to the Copper Alloy Bulletin by writing to Bridgeport Brass Company and asking that your name be added to the Copper Alloy Bulletin mailing list. Those already on the Bulletin mailing list will automaticaly receive copies, now in preparation.

METAL OUTLOOK

(Continued)

Reducing Maintenance by Using More Corrosion-Resisting Metals

Corrosion, the enemy of all metals, is finding more opposition from copper and its alloys. Destruction from corrosion means expensive maintenance, shutdowns, repairs and eventual replacement, all of which involve high labor costs. As a result, more attention has been given during the past year to specifying more corrosion-resisting alloys and combinations of metals. This explains the unprecedented demand for copper tubing for plumbing, heating and refrigeration lines, and for water wells. Copper tubing is also replacing outworn, rustable underground gas mains.

Outstanding is the large increase in the use of Duplex Tubing – copper-steel for ammonia refrigeration and for the handling of nitrogen compounds. Much saving has been effected over steel tubing because of increased service life, better heat transfer and reduced maintenance. Other combinations of Duplex Tubing are doing much for the processing of petroleum products, chemicals and foods.

Serious pollution of streams and harbors is responsible for a wider use of corrosion-resisting Duronze IV* (aluminum bronze) and Aluminum Brass condenser and heat exchanger tubing in the power, marine and chemical fields.

To fight corrosion from moisture and weather we find that manufacturers are using more silicon bronze alloys for bolts, nuts, screws, marine and pole line hardware, equipment for waste treatment and sewage disposal plants, paper mills, etc. Duronze III* (silicon aluminum bronze) and other aluminum bronze alloys are also more generously used for valve stems, pump parts, valve seats to reduce wear and increase service life.

To sum up briefly – metal fabricators are meeting rising costs by more carefully selecting metals and alloys that are physically suited to their requirements as exactly as possible, are tightening up on their manufacturing operations, and changing methods of manufacture for greater economy.

Progress at Bridgeport Brass

Many gains have been chalked up on the plus side of the ledger. 1948 was a big production year for the Company. At Bridgeport, Connecticut, the mills worked at capacity practically all of the time. New production records were made by our Tube Mill as more and more of the new equipment swung into action.

Our new mill at Indianapolis also greatly benefited from the additional equipment which made possible the production of commercial gauges of strip and sheet and a full range of rod sizes and shapes. Its substantial volume of copper water tubing in straight lengths and coils also helped its growing production picture. Thanks are gratefully extended to our Mid-Western and Western customers for their support rendered to this great new mill.

With many unsolved problems at home and abroad, 1949 promises to be a year of changing conditions. Customers should feel free to call upon our laboratories in Bridgeport and Indianapolis, as we wish to be as helpful as possible in regard to their metal problems. *Reg. U. S. Pat. Off.

For fabrication of the many thousands of articles of everyday use, Bridgeport offers a wide choice of alloys in many forms. Modern mills in Bridgeport, Conn., and Indianapolis, Ind., and a staff of experienced laboratory-trained men are ready to help our customers quickly with their metal problems.

Sheet – Rolls, Strips – Brass, Copper, Nickel Silver, Phosphor Bronze, Silicon Bronze, Aluminum Bronze for drawing, spinning, stamping, forming.

Rod–High-Speed, Free-Turning Brass and Duronze III Aluminum Bronze for screw machine operations. Also, Naval Brass, Silicon Bronze, Aluminum Bronze. Bronze Welding Alloys.

Wire–Brass and Silicon Bronze for making screws, rivets, bolts, nuts, nails. Phono Electric Bronze trolley wire.

Tubing–Copper for plumbing and heating; Condenser and Heat Exchanger Tubing; Brass and Copper pipe.

Plumbing Brass Goods. Traps, sink plugs, basket strainers, bath wastes, basin supplies, shower curtain rods; radiator air valves for one-pipe steam heating systems.

Automobile Tire Valves – for passenger cars, trucks, farm tractors – valve caps, cores, gauges.

Aer-A-Sol Insecticide–DDT pressure container type for killing household insects.

NEW DEVELOPMENTS

This column lists items manufactured or developed by many different sources. None of these items has been tested or is endorsed by the Bridgeport Brass Company. We will gladly refer readers to the manufacturer or other sources for further information.

Circular Slide Rule, only 4½" in diameter, can be used to multiply, divide, determine squares, square roots, cubes, cube roots, reciprocals and proportions. **No. 901**

Automatic Loading Devices for rotary and rack type gear finishing machines are said to maintain production rates as high as 300 pinions per hour per machine by means of gravity chute feed, eliminating need for arbors to mount gears and pinions. **No. 902**

New Miniature Lathe is said to combine features of standard lathes with specialized design of jewelers' lathes for use in machine shop, tool room and laboratory as well as by watchmaker and jeweler. Measures 10½" x 7¼" x 3¾", with speed range from 100 to 3000 rpm. **No. 903**

Vernier Scale Magnifier, essentially an optical glass 3½" to 4 power lenses in spring brass frame, clips over head of reading scale to simplify accurate reading on both sides of vernier calipers. **No. 904**

New Metal Castings Sealant is reported to permit salvage of many castings rejected due to porosity. Impregnation is by vacuum pressure method, suitable for aluminum, magnesium, bronze, steel and gray iron, it is claimed. Anodizing or plating coatings can be applied, and sealant resists hydrocarbons, water, salts, solvents and moderate acids or alkalis. **No. 905**

Self-Feeding Tube Expanders are claimed to provide uniform expansion through entire thickness of sheet. Designed for precision rolling of condenser tubes from ½" to 1½" od, units are said to be particularly effective in rolling bimetal tubes. **No. 906**

Pocket-Size Plater's Computer is said to furnish data quickly for all types of plating operations, such as plating time to deposit given thickness of metal, current density required to deposit given thickness, thickness resulting from established plating time at known current density, cathode efficiencies of plating solutions, etc. **No. 907**

Indianapolis Plant of Bridgeport Brass–powerful 3850-ton extrusion press making brass rod from a red hot billet.

BRASS, BRONZE, COPPER, DURONZE, NICKEL SILVER, CUPRO NICKEL

"Bridgeport" BRASS

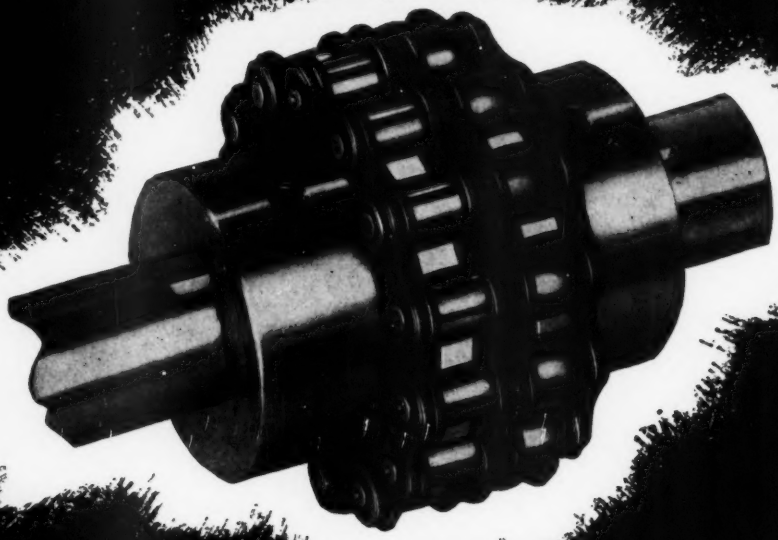
BRIDGEPORT BRASS

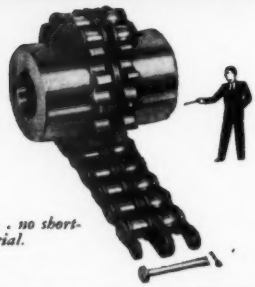
BRIDGEPORT BRASS COMPANY, BRIDGEPORT 2, CONN. • ESTABLISHED 1865

Mills at Bridgeport, Connecticut, and Indianapolis, Indiana • In Canada: Noranda Copper and Brass Limited, Montreal

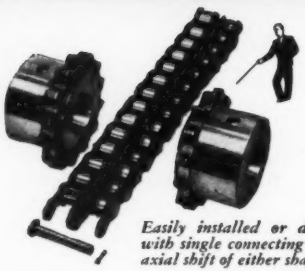
Warehouse Service with Slitting Facilities in Principal Cities

This coupling gives you TRUE F

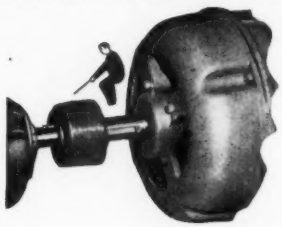




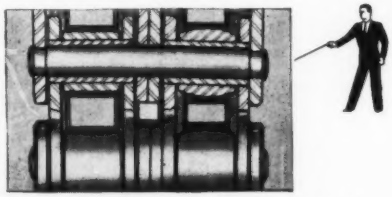
All-steel . . . no short-lived material.



Easily installed or disconnected with single connecting pin . . . no axial shift of either shaft.



Dampens transmission of pulsating loads.



Plus EXTRA flexibility . . . EXTRA shock absorption because the pins bend.

Flexibility without Backlash

BALDWIN-REX TRU-FLEX COUPLINGS

Truly flexible without backlash . . . shock absorbing . . . easily installed or removed . . . dampen vibration . . . accommodate misalignment and end play . . . long lived . . . only Baldwin-Rex Tru-Flex Couplings give you all these advantages.

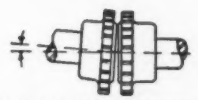
These efficient roller chain couplings are distinguished by their oversize convex rollers on one chain strand . . . an exclusive design that gives you better all-round performance, more protection and longer service. The convex rollers maintain only line contact with sprocket teeth and because of this line contact, the pins are designed to flex or bend. Thus, the couplings can accommodate misalignment and absorb greater torsional shock loads. Chains are fitted snugly to the sprocket assuring you far longer life than the "sloppy fit" of ordinary chain couplings. Backlash is completely eliminated. Tru-Flex Couplings have a constant capacity to transmit power.

There are no short-lived materials used in these couplings. Their all-steel construction assures you the maximum in service at minimum maintenance costs. They will operate efficiently under the same oil, heat or corrosive conditions as the shaft on which they are mounted.

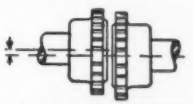
And you'll be amazed at how easily you can install or remove Tru-Flex Couplings. With their single connecting link, you merely wrap the coupling chain over the sprockets, insert the pin and secure the cotter. To remove, simply remove the cotter, withdraw the pin, and remove the chain. There is no need for an axial shift of the shaft or moving all the equipment.

For all the facts on Tru-Flex Couplings send for your copy of Bulletin No. 46-6. Write Baldwin-Duckworth Division of Chain Belt Company, 321 Plainfield Street. Springfield 2, Mass.

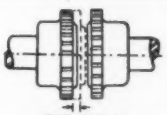
TRU-FLEX COUPLINGS ACCOMMODATE:



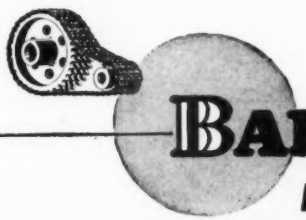
ANGULAR MISALIGNMENT



RADIAL MISALIGNMENT



END PLAY

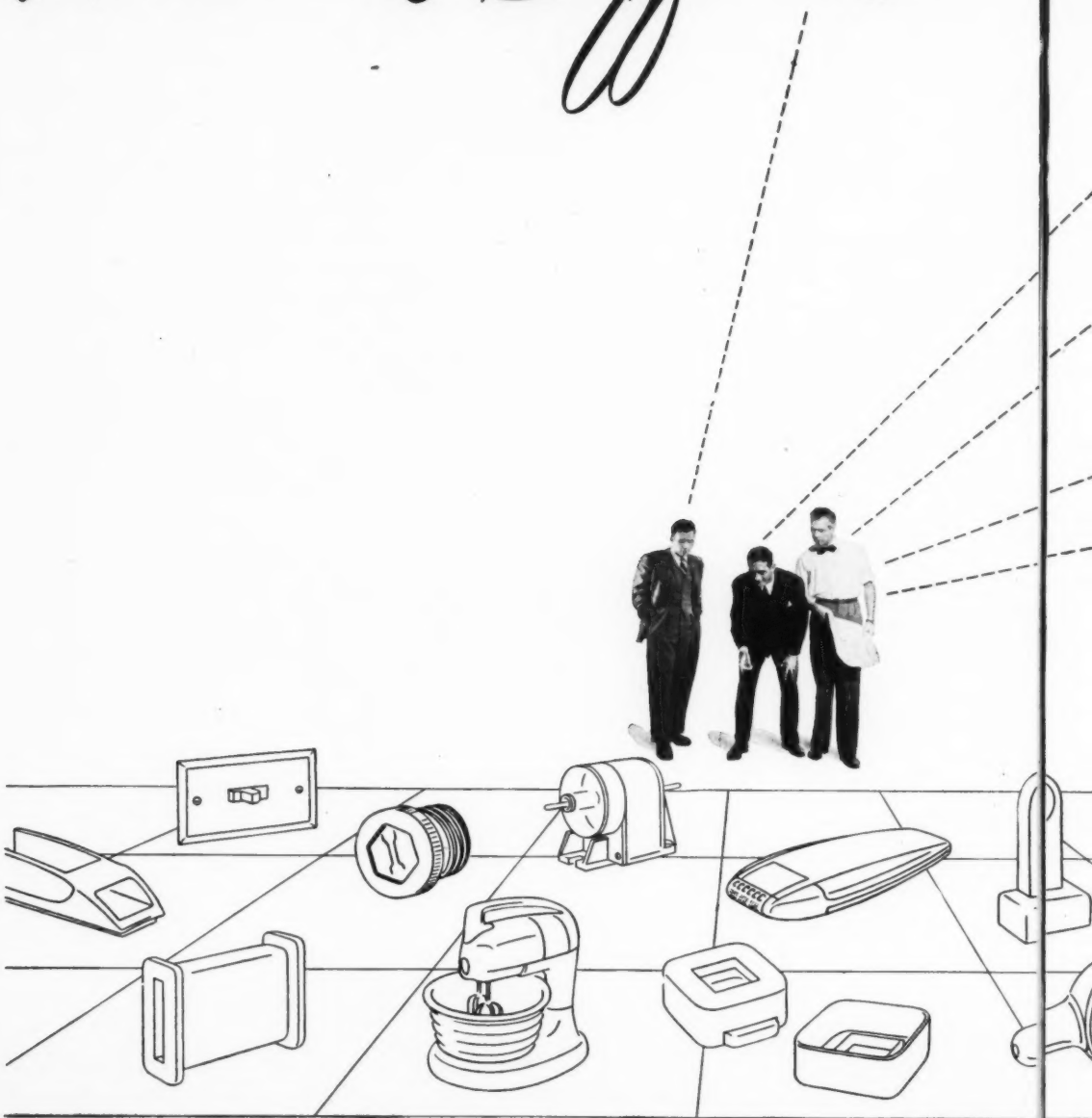


BALDWIN·REX

ROLLER CHAIN COUPLINGS

BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY

What's the Difference...



between LUMARITH XF and Standard Cellulose Acetate?*

A. Lumarith XF has 50 to 80 percent greater flame resistance.

Q. Are there other differences?

A. Yes, Lumarith XF has 25 percent greater impact strength than regular acetate. It is a hard flow formulation with an excellent balance of physical characteristics—including: heat resistance, form retention, resistance to cold flow and surface brilliance. Lumarith is available in a full color range that stops just short of crystal transparency.

Q. What does Lumarith XF have to offer the manufacturer of electrical parts and products?

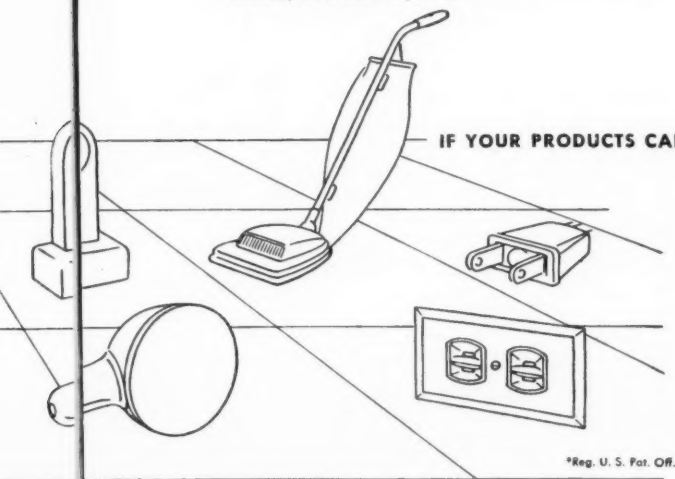
A. Lumarith XF has been developed especially for the electrical and appliance industry. It is a thermoplastic. That means it is moldable by high speed injection and extrusion . . . can cut production and finishing costs considerably. Its impact and tensile strength can produce parts of greater toughness and serviceability. Lumarith XF is available in a full color and transparency range. It is completely machinable without annealing.

Q. What about Underwriters' approval?

A. Products using Lumarith XF are receiving Underwriters' Laboratories approval.

Q. How can we know that Lumarith XF will work for our products?

A. Celanese offers its cooperation in testing and developing Lumarith XF in new applications. Case histories of successful switchovers to Lumarith XF are available for study by manufacturers and product planners. Write. Celanese Corporation of America, Plastics Division, Dept. D-6, 180 Madison Avenue, New York 16, N. Y.



IF YOUR PRODUCTS CAN benefit COSTWISE through injection or extrusion molding
benefit PRODUCTWISE through toughness, color, and finish
benefit SAFETYWISE through greater flame and heat resistance

LOOK INTO LUMARITH* XF

A *Celanese* Plastic

*Reg. U. S. Pat. Off.

For those who want better prints

faster

BRUNING BW WHITEPRINTERS

Model 21 Bruning Whiteprinter for moderate print production.

There is a Bruning Whiteprinter to meet the requirements of any drafting or engineering department . . . and every one of them is designed to make perfect prints of your tracings . . . fast.

In seconds after you turn on a Bruning machine you are producing copies that are tops in legibility. There is no time lost waiting for prints to dry . . . BW prints are ready for instant use as fast as they come from the machine. There is no time spent making negatives . . . BW machines make clear, sharp positive prints (black on white) directly from any copy that is drawn, typed or printed on a translucent material.

If you need sharp duplicate prints . . . big or small . . . on paper, card, film, or cloth, it will pay you to investigate Bruning Whiteprinters . . . the last word in efficient and accurate duplication of engineering and/or office forms.

CHECK THESE BW ADVANTAGES

Just plug in: Bruning Whiteprinters plug into standard 110 or 220 outlets, depending upon the size of the machine. No special wiring required.

No vents or exhaust fans: The BW process is completely odorless . . . can be performed anywhere in the office without the slightest offense.

No plumbing connections: There are no pipes to connect, no water to supply or drain away. Nothing to anchor the machine to one spot.

Wide variety of prints: BW prints can be made on light, medium or card weight paper with black, blue, red or brown lines. Also on tinted stocks, transparent paper, film and cloth.

A 1001 uses: A BW unit can reproduce a letter, invoice, chart, financial report or other document as easily and quickly as it makes perfect prints from engineering drawings. It is truly a company-wide machine . . . saving time and money for every department.

Send today **for full information.**

Let us send you a file of descriptive literature on Bruning Whiteprinters and BW materials. There is no obligation. It would be helpful to know approximately how many copies you plan to make a day and their average size.

Charles Bruning Company, Inc.

Since 1897

4736–38 West Montrose Avenue, Chicago 41, Ill.

New York - Chicago - Los Angeles - And 11 Other Cities

Other Bruning products you should know about — Drafting Machines - Drafting Room Furniture - Slide Rules - Erasing Machines - Surveying Instruments - Tracing Papers and many other products.

. . . when machine-builders "buy the idea" of AMERICAN PHILLIPS SCREWS

PRODUCTION "PAYOFFS" climb up toward jackpot levels, where American Phillips Screws are policing costs in all assembly departments. Workers work faster and better. Shiny surfaces are never gouged. For American Phillips Screws and drivers are fumble-proof, skid-proof, slash-proof. And they can be handled *by anyone* with such ease and speed that time-savings average *50% over slotted screws.*

STEADY "PLAYS" are sure to be attracted by smartly styled machines, assembled with modern, attractive American Phillips Screws . . . the screws with the universal crossed recess. No burred heads to snag clothes. No loosening of screws under vibration and incessant use. And no matter what *you* make or vend, chances are you can profit *doubly,* too, through the production savings and merchandising power of American Phillips Screws. Write.

4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN SCREW COMPANY, PROVIDENCE 1, R. I.

Chicago 11: 589 E. Illinois St. *Detroit 2:* 502 Stephenson Building

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

COMMON SENSE ASSEMBLY ENGINEERING

Puts Fastening Costs in a Better Light

MAKES PARKER-KALON TYPE Z SERVE DUAL PURPOSE . . . SAVES 35%

To make the price of these adjustable fixtures as practical as the lamp itself, the manufacturer—**Penetray Corp., Toledo, Ohio**—had to "go light" on fastening costs. That meant fast assembly with as few operations as possible.

But the fasteners had to serve a dual purpose . . . attach the plastic Hemisphere socket to the fixture's metal base (or gooseneck) and function as pivots to permit a 180° sweep of the socket.

P-K Self-tapping Screws were selected because they not only eliminated troublesome tapping and tap breakage, but also provided the hardened tips of the screws to serve as long-wearing pivots. Thus, they permitted a simpler, smoother design, and helped brighten the cost picture with a 35% assembly saving!

Why not examine your own fastening methods in the light of common sense assembly engineering. Very likely you, too, can benefit by switching to the simpler Parker-Kalon method. Call in a P-K Assembly Engineer. He can show you that in 7 out of 10 cases, use of P-K Self-tapping Screws saves up to 50% in assembly work hours. If you prefer, mail assembly details for recommendations. Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

Sold Only Through Accredited Distributors

Two P-K Countersunk Oval Head Type "Z" Self-tapping Screws fasten plastic socket to metal base of fixture and also serve as pivots for Hemisphere socket which moves 180° in a vertical plane. P-K Screws need only to be driven in plain holes . . . form their own threads . . . assure a strong fastening.

P-K® *The Original*

A TYPE AND SIZE FOR EVERY METAL AND PLASTIC ASSEMBLY

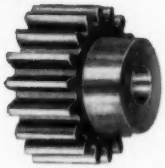
PARKER-KALON SELF-TAPPING SCREWS

PARKER-KALON PRODUCTS COLD-FORGED SOCKET SCREWS, WING NUTS, THUMB SCREWS • HARDENED SCREWNAILS AND MASONRY NAILS SHUR-GRIP FILE AND SOLDER IRON HANDLES • METAL PUNCHES • DAMPER REGULATORS AND ACCESSORIES

doing ONE THING well...

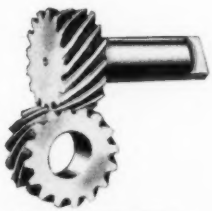
...GEARS FOR OVER 57 YEARS...

PHILLIE GEAR

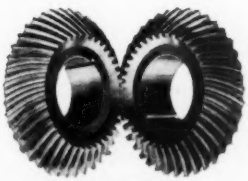


Spur Gears up to 150" diameter (one piece). Bolted section gears even larger.

Bevel Gears up to 96" diameter.



Spiral and Helical Gears up to 150" diameter.



Curved Tooth Spiral-Bevel Gears up to 48" diameter.

We *believe* there is merit in "sticking-to" one line of business for over a half century, and we *know* that there is deep satisfaction in growing year-after-year, particularly when that growth reflects user confidence and continued patronage.

Today, we have one of the largest and most modern plants in America devoted to the design and manufacture of Gears for Industry and Transportation. In fact, there is no type, size, or quantity of gear which we do not make, and that is just why we have been known for years as *"Gear Headquarters."*

Write for your copy of our latest 68-page *"Gear Book,"* and please use your Business Letterhead when requesting it.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.
NEW YORK • PITTSBURGH • CHICAGO
IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

a complex shape - at *lower* cost

SIZE—14¼" x 11"
WEIGHT—3 Lb.
WALL THICKNESS—Approx. 1/16" overall
CORING—No machining—all openings and bosses cored
STRENGTH OF THE ALLOY—
Over 40,000 Lbs./Sq. In. Tensile
Over 40 Ft. Lbs. Impact—½" Sq. Bar
(Strength Values Determined on Test Bars)

another successful product designed for ZINC DIE CASTING

Numerous problems, common to the design of many metal parts produced today, were solved when this main frame for a combination wire recorder-radio-phonograph was produced as a one-piece zinc die casting. This is an outstanding example of the extreme complexity of shape possible by the die casting process.

The tag at the top reveals pertinent details of this amazing zinc die casting, but it is suggested that you closely examine the above photograph of the casting and ask yourself "How else could it be produced at reasonable cost?" Bear in mind, too, that this main frame supports most of the "innards" of the machine shown at the right and, therefore, must be dimensionally accurate to position and hold all operating parts in perfect alignment. All of the assembly bosses, studs, and recesses are obtained in the casting operation.

This combination unit is just one of many successful products designed for zinc die casting in the field of radio and communications. Typical applications in other major industries will be covered in future advertisements in these pages.

*There are 20 additional zinc die castings in the assembly of this product.

SEND FOR THIS BOOKLET ➡

A new booklet—just off the press—has 64 pages of photographs depicting zinc die castings in the assembly of a wide variety of products in many fields. Send for your copy today!

ZINC
FOR DIE CASTING ALLOYS

THE NEW JERSEY ZINC COMPANY, 160 Front St., New York 7, N. Y.

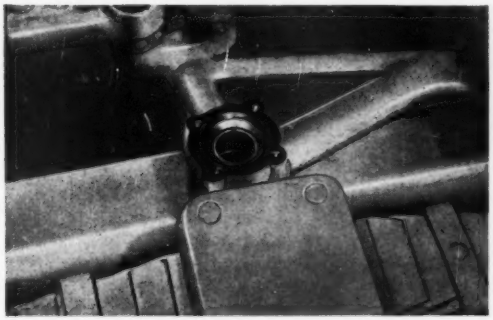
The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

Torrington Needle Bearings

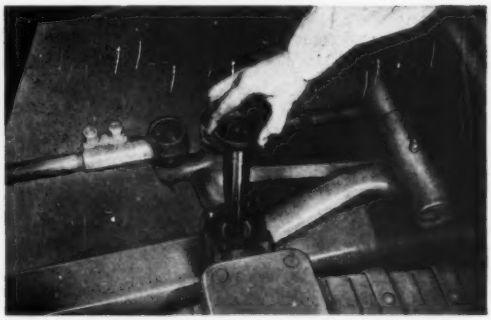
Keep Upkeep Down

in "Caterpillar" Diesel Tractors

Heavy farm chores and tough construction jobs are a matter of course for "Caterpillar" Diesel DW10 Tractors. One feature owners like is a rugged design needing little upkeep. In governor, brake pivot shaft, steering gear and steering bellcrank, long service life is secured with efficient Torrington Needle Bearings.



The bellcrank application in steering control shows how these high-capacity, anti-friction units fit into compact designs. Two Needle Bearings mounted with close fits keep mating parts in alignment. Freedom from wear maintains close bearing clearances and eliminates the need for readjustment.



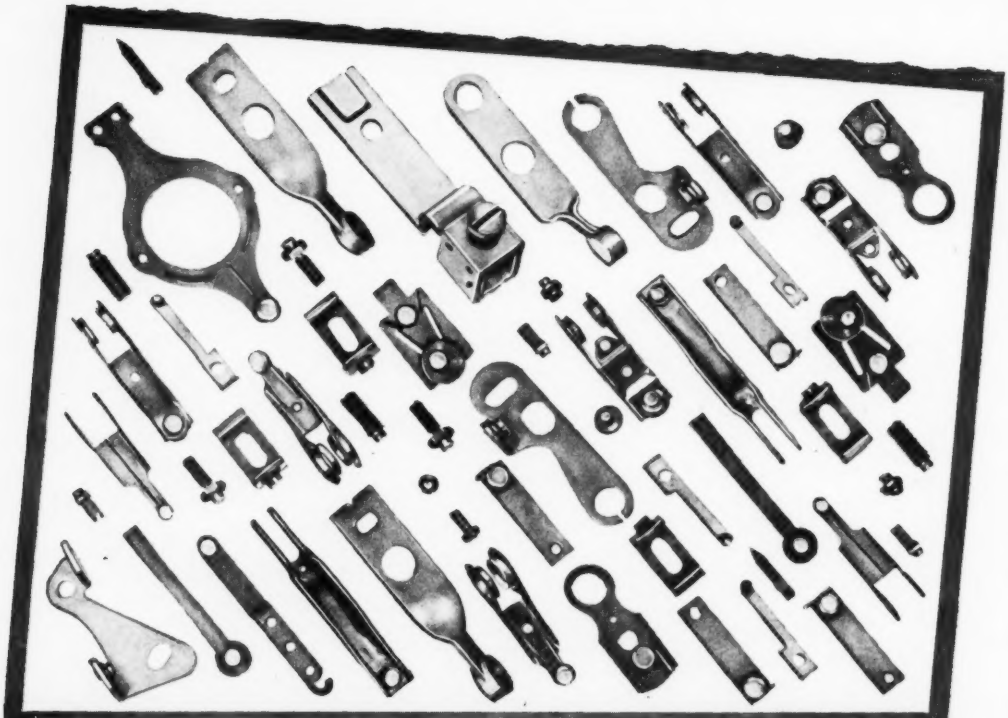
Related parts of the assembly are simple—a plain machined bore for a housing, a hardened and ground shaft for an inner race. Fabrication is easy, and installation a quick arbor press operation. No retaining devices are needed. Such Needle Bearing features help keep manufacturing costs down.

Machinery you build or operate can be improved in operation and service life with Torrington Needle Bearings. Consult our engineers on your specific application requirements. THE TORRINGTON COMPANY, Torrington, Conn. or South Bend 21, Ind. District offices and distributors in principal cities.

TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller

Straight Roller • Ball • Needle Rollers



Sized, Shaped and Engineered Precisely to Your Requirements

That's the advantage of bringing your contact assembly problems to WILCO

Wilco Contact Assemblies

Whether you choose assemblies of silver, platinum, tungsten, special alloy or powder metals . . . assembled to thermostatic bimetal, steel, beryllium copper or other nonferrous metal springs, blades, brackets, arms and screws . . . you'll find them precisely conforming in size, shape and material to your exact requirements and engineered for precision performance.

In fact all WILCO PRODUCTS can be precision-tailored to manufacturers' individual requirements, including

THERMOSTATIC BIMETALS All temperature ranges, deflection rates and electrical resistivities

SILVER CLAD STEEL For industrial use

ELECTRICAL CONTACTS Silver—Platinum—Tungsten—Alloys—Sintered Powder Metal

NI-SPAN* C Constant Modulus Alloy; also low and high expanding Ni-Span Alloys

JACKETED WIRE Silver on Steel, Copper, Invar and many other combinations

SPECIAL ALLOYS including high conductivity, high strength Copper Alloys

ROLLED GOLD PLATE and GOLD FILLED WIRE

Whether your requirements are for individual Wilco materials or for assemblies supplied by us complete . . . Wilco engineers will gladly help you meet them successfully.

THE H. A. WILSON COMPANY, 105 Chestnut St., Newark 5, N.J. WILCO Branch Offices: Chicago, Detroit, Los Angeles, Providence

SPECIALISTS FOR 34 YEARS IN THE MANUFACTURE OF THERMOSTATIC BIMETAL • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS AND SPECIAL ALLOYS

*Reg. Trade Mark The International Nickel Co., Inc.

Premiums for Producibility

IT IS QUITE PROPER to pay little attention to principles if they are relatively unimportant. Even the normally all-important cost factor must sometimes be ignored. If the need for a product or machine is urgent, it may be perfectly justifiable to double its cost in order to save time. This situation was prevalent during the war.

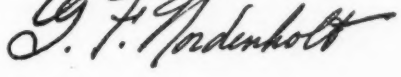
With the passing of time, relative values change. Inefficiencies that were condoned during an emergency are analyzed microscopically when conditions return to normal. Criteria that were discarded are rescued, framed and with perhaps different phraseology are presented as new slogans. Past extravagances and waste are condemned.

No one should be criticized for the swinging of the pendulum between the extremes of almost total abandonment of economical methods to strictest accountability for all expenditures. That is the way humanity progresses. Man can learn only by making mistakes and then getting himself out of the mess.

During the late war the whole world became amazed over the phenomenal production of U. S. planes and military equipment. After the war, despite this record breaking performance, the usual charges of inefficiency and extravagance were levelled against guilty and innocent alike. The furor did not amount to much. Most people shrugged off the charges with the comment that war is inherently wasteful.

To-day the U. S. Army Air Forces are leading the way in instituting a new factor in war production. Competing designs of aircraft, which up to now have been rated only on their performance characteristics, are now judged with an additional factor included, namely, producibility. Out of a total of 1000 points possible, a maximum of 800 can be given the design of plane for performance points such as speed, maneuverability, rate of climb and others. Based upon an engineering diagnosis of the design, a maximum of 200 points can be awarded for the producibility of the design. Thus, twenty percent of the credit points are allocated to the economical production features of the design that make possible low cost manufacture. The "fancy" and "tricky" designs, and the ideal but disproportionately costly designs will find little acceptance under these new A.A.F. acceptance ratings.

This recognition of the importance of efficiency of production in military equipment has a great deal of significance. In the last two wars the side that won was guilty of tremendous extravagance and waste. With the rapid dwindling of natural resources it will be impossible to have a "repeat performance" without most serious consequences. Perhaps the new A.A.F. ratings mark the awakening to the fact that the victory in future wars will go to the side that uses its natural resources and man power most efficiently and most effectively.



Nothing Rolls Like a Ball

You couldn't select
a finer bearing

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE · Division of GENERAL MOTORS · BRISTOL, CONNECTICUT

Meeting the Engineering Impasse

The dynamic approach as opposed to the static approach when the solution to an engineering problem fails to materialize.

THE OLD ONE about the weary homeward bound traveler who, after bumping repeatedly into the same tree, finally mutters "Losht in a forest" will probably be told generations hence. In this poor fellow's predicament, we recognize our own frailties and sympathize with him deeply.

Every engineer, at one time or another, after bumping into an apparently insolvable problem without making an inch of progress has sat back, overwhelmed by feelings of incompetence and frustration, convinced he is lost in the forest.

To the man in this predicament, there is only one way out—a return to familiar and reassuring step-by-step engineering procedures coupled with an open-minded attitude regarding all available data.

Impossible situations usually look less formidable if we step back from the problem to get a better view.

Why An Impasse

Most engineering impasses come about because of:

1. Failure to "see" the problem in the beginning.
2. Failure to set up job requirements.
3. Failure to organize the attack on the problem.
4. Failure to use available or significant data.
5. Blind acceptance and use of empirical solutions, which are not always applicable to the conditions.
6. Not enough engineering knowledge of the subject.
7. Mental complacency.

Occasionally the job may be too big for the man; but mostly, if he works up a mental or a paper score card, listing the foregoing causes for failure, and honestly rating himself on these points, he will have enough information to reform his program.

One approach, used by a well known engineer, is admirable for its simplicity. He points out that the biggest mistake anyone can make is not to make decisions. Statistically proven is the fact that the more decisions a man makes, the higher his percentage of correct decisions will become. Hence, this engineer reasons; force yourself to make decisions. Following his own advice, whenever he bogs down, he makes up his score card. And then opposite each point on the card he lists facts. For example, if he checks failure to set up job requirements as a reason for his predicament, he then decides whether it is possible to set these up, or whether these must come from another source. If from another source, he wastes no time in recognizing that fact and in doing something about it. But it is up to him, he knows that the situation will not improve until he does what he has to do.

This same engineer maintains that no situation can arise in which decisions cannot be made. Occasionally they appear impossible because he does not know enough about the problem to solve it. But again he points out that even if the problem is temporarily abandoned while he takes time out to equip himself with more knowledge or facts, he has, in effect, made two important decisions: (1) To abandon his futile efforts, while (2) he increases his knowledge.

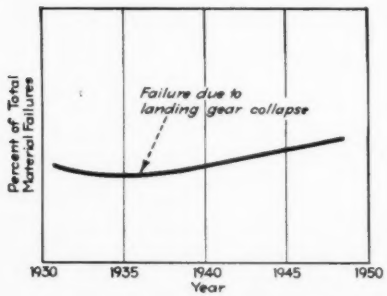
This may be interpreted as a sign of failure by his superior, but on the other hand, a frank admission is better than an attempt to muddle through with disastrous results later on. Personal stock taking and subsequent decisions may have the effect of putting a man in an unfavorable light, but more often than not, once the Gordian Knot has been cut, a man is freed of mental obstacles and is able to bring his full talents to bear on the problem, thus heightening his chances of solving it.

Innumerable examples of the dynamic approach to engineering problems exist in the files of successful engineering groups. No matter if the problem has to do with bath tubs, battle ships, automobiles or sewing machines, it will usually yield to an organized dynamic approach when static, empirical methods prove ineffective.

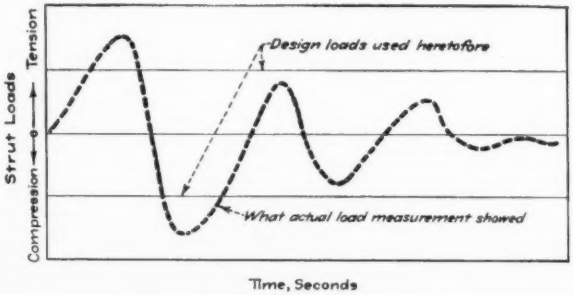
Often the structure of a brilliant, well defined analysis goes unnoticed in the activity that follows the solution. Still more often, a problem is solved by a series of steps arrived at intuitively.

In both cases, the approach remains

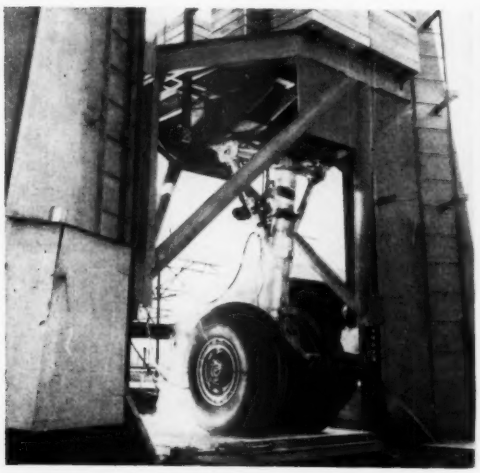
Safer landings for planes like this . . .



. . . Meant facing unpleasant facts



. . . Studying basic concepts of design



. . . And running tests

. . . To develop safer landing gears

hidden from other engineers who recognize it only as "knowhow". But if exposed and defined, "knowhow" is nothing more than a knowledge of sound analytical concepts and the ability to apply them to specific solutions.

Recently a paper was given before members of the Institute of Aeronautical Sciences that described an engineering project undertaken at Lockheed Aircraft. It makes interesting reading for its engineering contents, but is more important to most engineers for its account of how one engineering group distinguished itself, simply by going back to the beginning, reorganizing their program and then carrying on to a successful conclusion. The story is worth telling.

The problem was complex. For many years, aircraft engineers had been refining their methods for structural analysis and design of aircraft landing gears to keep pace with the development of larger and more complex aircraft. Early gear had as shock absorbers rubber bungee cords, which were gradually displaced by damped springs, air shock struts and finally air and oil shock struts. Early landing gear was fixed in position. New gear had to be fully retractable and equipped with powered retracting drives. Added to this was the problem of incorporating wheel shimmy dampers, improved brakes and other refinements. As a result, landing gear design had long since ceased to be an afternoon's work for one man. However, in spite of all that was done during design to produce satisfactory gear, the number of structural failures increased.

In one report issued by the AAF Office of Flying Safety, covering a period of three months in 1945, there were sixty military aircraft accidents caused by landing gear collapse, of which thirty occurred during the normal landing roll. This report covered only army aircraft operating in the U. S. Other studies showed that in aircraft accidents resulting from material failures, more were caused by landing gear failures than all other material defects combined.

Augmenting this distressing situation was the fact that landing gear design loads had been increased steadily; with the only result that landing gears had become proportionately heavier with no appreciable improvement in their performance.

Clearly something was wrong in landing gear design, but engineering complacency had set in and few people realized that an impasse was pending.

It remained for this engineering group to call a halt to the elaborate and costly design ritual that was leading only to heavier landing gear.

Because of the careful quality control of the parts going into the landing gears such as forgings, shock struts, hinge pins and tubes, which are often individually tested to destruction to check their operation or their load carrying capacity, it was evident the cause of landing failures was more fundamental. Experience indicated that few defective parts, as such, ever reach final assembly. Furthermore, (because of the relatively few number of times such parts are stressed) fatigue failure in landing gear parts seldom occur.

Recognizing this, the group returned to a study of the nature of the applied loads on landing gears and the loading criteria that had been developed for design. Out of this study was developed an entirely new approach to the problem of landing gear design.

Briefly what they did was this. First they examined load criteria; although airplane landings produce dynamic loads on the gear, it had been standard design practice for over forty years to express these loads as static loads. Hence gears were being analyzed as though they were static load structures. Furthermore, each design loading condition, corresponding to various landing and taxiing attitudes, had been arbitrarily determined as a result of various service failures. So, in effect, these design loading conditions represented nothing more than a consensus of opinion.

The Lockheed design group, after long study and reference to the work of other investigators, came to the conclusion that this approach was wrong. Instead of basing all their work on elaborate guesses, they decided to find out what the landing gear itself had to "say" about the loads applied to it during landing and taxiing. Although it promised to be a long, costly program, they wanted to find out how landing gears were actually loaded.

The next step was to review thoroughly all literature relating to the action of dynamic loads on structures and to study previous investigations on landing gears. From scattered evidence, it was deduced that many failures come from dynamic overloading of the structure.

They recognized that the landing gear is an elastic structure with a natural frequency in the fore-and-aft direction, and that dynamic forces applied rapidly to elastic structures produce stresses and deflections unlike those from the same forces applied slowly. Also, the resulting dynamic stresses and deflections are higher than static values by an amount depending on the relationship between the rate of application of the applied force and the natural frequency or response of the structure.

A number of landing gears were analyzed. It was found their natural frequencies were of the same order as wheel spin-up rates. Hence there was a random chance large dynamic loads could exist during normal landing. Also in braked landings, with the wheel skidding alternately through puddles and over dry areas, the rapid variation in drag loads accompanying changes in the braking load, could possibly produce forcing dynamic loads substantially in resonance with the natural frequency of vibration of the landing gear.

Having deduced these probable reasons for failure, they considered possible solutions including increased strength, increased or decreased natural frequency, wheel rotation before landing, and damped fore-and-aft motion of the gear.

For practical reasons all but the last solution were dropped. To check themselves, the group then designed a hydraulic damper for the drag system of the Constellation landing gear. The complete gear was mounted in a drop testing machine. Some drop tests were run with the old rigid drag system and others with the hydraulic damper installed. The forces in all members were measured with strain gages and a recording oscillograph. Wheels were pre-rotated in reverse to simulate the effect of wheel spin up forces during initial contact of the wheels with the ground.

The results of the tests corroborated the conclusions reached in the study. In the damped landing gear, transient structural loads were well below those in the undamped gear. Further tests on an instrumental plane bore out the drop test results.

As a result, the way was opened to a new engineering approach to the design of landing gears, promising lighter, safer structures and more comfortable airplane landings.

Stripped of its locale and details, every engineer is familiar with the theme of this short story. The impasse, the soul searching, the quest for more knowledge and the fresh attack on the problem form a logical series. And the precept, as pointed out earlier in this article, is that a dynamic engineering approach must be used to solve problems that do not yield to static methods of solution. Only wide awake engineering will produce the results that are reflected in effective design progress.

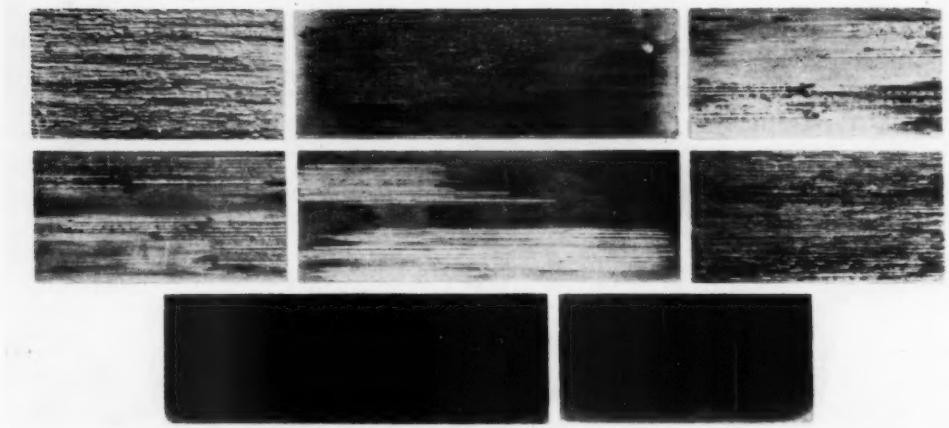


Fig. 1—Appearance of various alloys after reciprocating wear test; actual results are shown in Table III. The surface hardened Type 410 stainless steel specimens, bottom, show little wear as compared with untreated alloy specimens, top and center.

Surface Hardened Stainless Steels

Applications of stainless steels to parts that must resist wear and corrosion extended by a surface hardening process known as Malcomizing. Details of process and its effect on materials.

VINCENT T. MALCOLM
Director of Research
Chapman Valve Manufacturing Company

SERVICE CONDITIONS may require that mating machine members be resistant to both wear and corrosion. Stainless steels of either the ferritic or austenitic type have good corrosion resistant properties, but the wear and seizure characteristics of these materials normally is poor regardless of the type of heat treatment used.

However, by a specially developed nitriding process known as Malcomizing, the surface hardness of any of the basic types of stainless steels can be increased up to 1,000 Brinell, with a corresponding increase in wear resistance, erosion resistance, and resistance to seizure. In this process, dissociated ammonia gas first is used to reduce any oxides that may have formed on the surface, after which ionized ammonia gas is ued to add nitrogen. The nitrogen absorbed into the surface combines with the chromium in the steel to form finely dispersed, insoluable chromium nitrides, and sets up a highly compressive stressed surface. This explains, to a great extent, the fact that the hardened steels retain their hardness when used at elevated temperatures for long

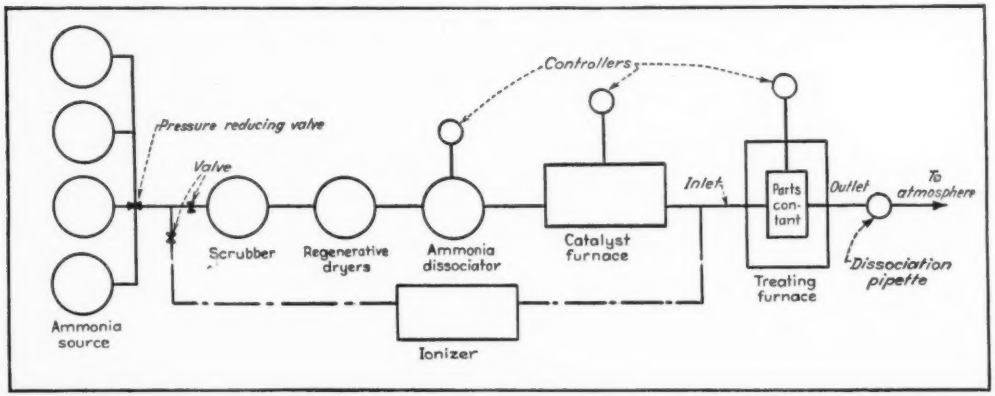


Fig. 2—Flow diagram of the case hardening process. In the first step, dissociated ammonia gas flows to the parts container through the top line where the active hydrogen in the gas reduces any oxides present on the surface. In the second step, gas flows through bottom line and, being ionized, adds nitrogen to surfaces of the parts. A case of 0.015 in. takes 30 hours.

periods of time. Softening, therefore, occurs only when the steel is subjected to such an excessive increase in temperatures that agglomeration or decomposition of chromium nitrides takes place.

The flow diagram, Fig. 2, illustrates the steps in the process. The parts to be hardened are placed in special steel containers; they are uniformly spaced and separated by layers of copper gauze. The containers then are sealed, placed in the treating furnace, and connected to gas inlet and outlet lines. Ammonia gas from the supply tanks passes through the pressure reducing valve, the scrubber, the drying tower, and into the dissociator, which is operated at 1,400 F. From the dissociator it passes through the catalyst furnace, which is held at 1,200 F. and from there into the parts container in the treating furnace, where the active hydrogen gas reduces the oxides on the surface of the parts. During this preliminary treatment, the furnace is held at low heat, the maximum permissible temperature being 850 F. The duration of this treatment varies with the amount of material in the containers, but is never less than four hours.

In the next step, the ammonia gas is by-passed from the dissociator into an ionizer, where it is acted upon by an electric discharge. It passes from this ionizer to the container. During this treatment, the work is held between 920-1,050 F for a period of time depending on the type of steel being processed and on the depth of case that is required. Approximately 30 hr are required for a case depth of 0.015 inch.

There is practically no distortion during the process, the only distortion occuring if the parts are improperly supported while at temperature, and only then if the parts are long and slender. Even these parts can be cold straightened without damage to the case or core. However, in general, parts to be hardened should be machined to wear tolerance dimensions and stress relieved before hardening. If annealed bar stock is used and no deformation is caused by machining operations, the annealing treatment can be eliminated.

Table I—Heat Treatment Prior to Surface Hardening

Material		Suggested Heat Treatment
Type	Number	
Austenitic Stainless Steels	302, 303, 304 321, 347	Heat to from 1,800 to 1,900 F. Hold at temperature for from 10 to 30 min depending on part size. Quench in water or cool rapidly in air.
	316, 317	Heat slowly to 1,600 F and hold until temperature of part reaches equilibrium. Increase temperature to 1,800 F and hold. Quench in water or cool rapidly in air.
	325	Heat slowly to 1,700 F until completely soaked. Cool slowly in furnace.
Martensitic Stainless Steels	410, 416 420	Conventional quench and temper may be used, but for best results heat slowly to from 1,560 to 1,580 F and soak thoroughly. Quench in oil or cool rapidly in air. If required, draw at a temperature above 1,000 F.
Ferritic Stainless Steel	430	Heat to 1,600 F and soak thoroughly. Cool slowly in furnace to black heat, then in air to room temperature. If heavily stressed, relieve at 1,200 F to avoid distortion or strain blemishes.

The recommended heat treatment for raw stock varies with the composition of the steel. As indicated in Table I, Types 302 to 347 stainless steels should be fully annealed. Straight chromium type steels should be heated to the hardening temperature, cooled in air or quenched in oil, and tempered at 1,000 F. These treatments give the optimum physical and corrosion resistant properties to case, and insure a tight case of maximum hardness. If any parts are heavily stressed by machining, cold working, or forming, they should be stress relieved at 1,200 F before case hardening.

Properties of Malcomized Steel

CASE DEPTH—The case depth produced is limited by the type of stainless steel processed. For instance, with a 6 per cent chromium—½ per cent molybdenum (Type 502) stainless steel, or 13 per cent chromium (Types 410-416) stainless steel, case depths of 0.020 in. may be obtained; while

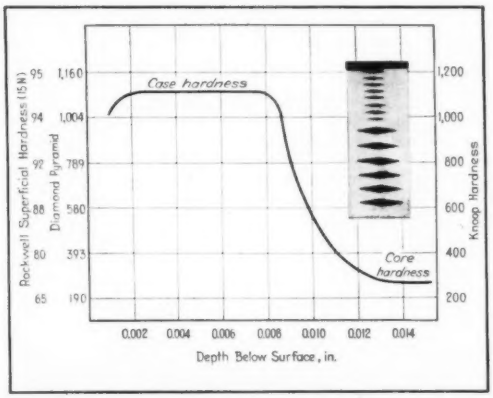


Fig. 3—Case depth and hardness of surface-hardened, Type 304 stainless steel. The insert, upper right, shows the Tukon diamond impression at various distances from the surface.

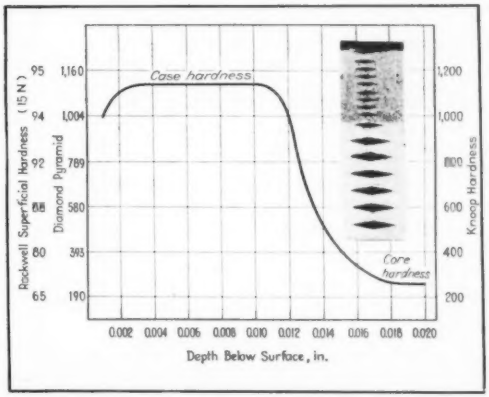


Fig. 4—Case depth and hardness of surface-hardened Type 410 stainless steel. The insert, upper right shows the Tukon diamond impression at various distances from the surface.

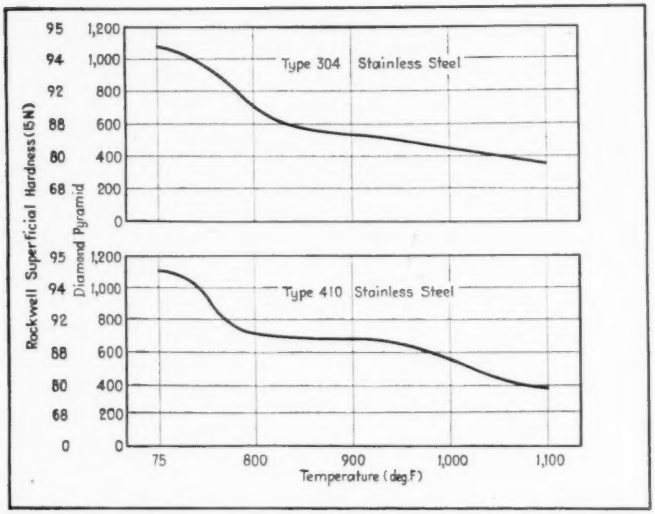


Fig. 5—Hot hardness values of the case for Types 304 and 410 stainless steel.

the maximum case depth obtainable with austenitic steels (Types 302, 304, 316 and 347) is limited to 0.010 inch.

As indicated in Figs. 3 and 4, maximum hardness occurs several thousandths in. below the outer surface of the steel. Thus, if subsequent lapping, grinding or otner surface finishing operations are necessary, 0.002 to 0.003 in. of material can be removed without affecting the wear resistance of the surface. Lapping or grinding also can be employed to make dimensional corrections after hardening, since the material may increase in size from 0.0005 to 0.001 in. per surface as a result of the process.

HARDNESS — The engineer usually looks upon hardness as a means of resisting plastic deformation in areas of contact. Therefore, in surface hardened stainless steels the best definition of hardness is, "that property of mechanical resistance that is possessed by the outer layers of solid metals." In Table 2 are listed the hardnesses of various materials at room temperature while Fig. 5 illustrates the hot hardness values of case hardened stainless steels.

WEAR RESISTANCE — Resistance to wear and abrasion does not necessarily increase directly with the hardness of a part. Both the hardness at heat and toughness of the surface layer of metal are important factors in determining wearing qualities. Hardness increases the resistance to penetration, scratching and displacement of metal, while toughness makes it difficult for small particles to be torn off the surface by an abrasive action. The wear factors obtained on various types of stainless steel are listed in Table 3. This wear factor is the unit wear value between two parts in grams per sq. in. per ft. multiplied by 10⁸; the higher the wear factor, the higher is the rate of wear.

While these wear tests may be used quantitively, they are applicable to the prediction of service life only when used in the same general manner as the laboratory test, which was especially designed to duplicate reciprocating wear and seizure. To understand wear, it is necessary to have a knowledge of its mechanism in practical service gained by pure reasoning and good metallurgical and machanical common sense, together with much experience by the trial and error method. Only then can test equipment be constructed that will reproduce the particular condition found in service. When this is done, it will be found to be far superior in the prediction of relative wear in service than the "blind" standard wear test so often quoted in the literature. Most of the scattered information on wear shows much confusion in the test methods, in the interpretation of test methods, and finally as to the definition of wear.

The machines used for these wear tests consist of two carefully aligned specimen holders. Through a speed reducing and eccentric mechanism, the lower holder describes a reciprocating motion through a stroke of two in., sixty times per min. The specimens in contact are rubbed against each other under constant loading and without lubrication. The results of these tests are determined by dividing the loss of weight of the specimen during the run (10,000 strokes) by the projected area of contact and length of travel.

The specimens are prepared for this test by grinding them at right angles to each other and by holding their length and width to a tolerance of not more than—0.001 in. The specimens are finished in a standard way, so that the finish can be duplicated.

This same equipment can be used to determine wear resistance at elevated temperature. The hardness of a stainless steel case decreases at elevated temperatures until the temperature reaches 1,000 F. At this temperature, the curve of hardness versus time becomes asymptopic at a residual case hardness of approximately 600 Knopp Hardness Number, which is more than the hardness of most other materials that may be used at this temperature.

FATIGUE RESISTANCE—One of the most important properties of surface hardened stainless steel is its resistance to fatigue, which is brought about by the high residual compressive stress in the surface layers. Thus, the tendency toward the formation of pits and tension cracks is greatly reduced. Fatigue resistance to over-stress in dynamically loaded parts is increased so that even should pits form, they are less hazardous as starting points of failure. Fret-

Table II—Erosion Resistance of Materials

Material	Hardness	Depth of Penetration, In.
12 Percent Chromium (Type 410) Case Hardened Stainless Steel	1000[1]	0.00045
18–8 Low Carbon (Type 304) Case Hardened Stainless Steel	1000[1]	0.00052
0.60 C Stainless Steel	514[2]	0.00120
18–8 (Type 304) Stainless Steel	220[2]	0.00087
12 Percent Chromium Stainless Steel (Type 410)	285[2]	0.00024
Nickel Beryllium	293[2]	no test

[1] Knoop Hardness [2] Brinell Hardness

Table III—Wear of Materials

Material	Wear Factor
12 Percent Cr. Stainless Steel (Type 410) vs. 12 Cr. Stainless Steel (Type 410) Both Case Hardened	0.84 (smooth)
18 Cr.-8 Ni. Low Carbon Steel (Type 304) vs.18 Cr.-8 Ni. Low Carbon Steel (Type 304) Both Case Hardened	0.91 (smooth)
12 Percent Cr. Stainless Steel (Type 410) Case Hardened vs. 12 Percent Cr. Stainless (Type 410) Heat-Treated to 302 BHN	1.59 (smooth)
0.60 C Stainless Steel vs. 0.60 C Stainless Steel (BHN 500)	45.0 (seized)
Nickel Beryllium vs. Nickel Beryllium	605.0 (heavily scored)
Stainless Iron (BHN 302) vs. Stainless Iron (BHN 302)	1383.0 (heavily scored)

Table IV—Physical Properties of Case Hardened Steel

Physical Properties	Stainless Steel Type 410		Stainless Steel Type 304	
	As Annealed	Hardened	As Annealed	Hardened
Tensile Strength, psi	130,150	118,750	89,850	87,500
Yield Point, psi	109,300	95,360	51,900	47,600
Elongation in 2 in., percent	20	18	56	56
Reduction in Area, percent	60	52	70	66
Brinell Hardness of Core	321	280	170	170
Brinell Hardness of Case	.....	990	.....	1,010
High Speed Fatigue Value–50 percent of tensile strength to failure	5,425,000	20,000,000	680,000	20,000,000
Charpy Impact Strength, ft lb	68	50	.....	.....
Core Bend Test, deg	180	180	180	180
Case Bend Test, deg	.....	70	.....	75

ting conditions found in hardened stainless steel are almost absent in surface hardened stainless steel.

However, this advantage of increased fatigue resistance is partly offset by the fact that hardened layers are sensitive to sharp blows at the edges of holes, sharp corners, and threads, because of low plasticity. If damage does result from a blow at these points, the protective stress in the layers collapses, and the properties of the case are impaired. Therefore, care must be used in the design of fillets, corners, and threads to obtain best service results.

EROSION RESISTANCE—In addition to high abrasion resistance and hot hardness, case hardened stainless materials also have good erosion resistant properties. Results are based on tests of 100 hr duration using steam at a pressure of 150 psi, a temperature of 300 F, and a velocity of 3600 fpm. Specimens of $1\frac{1}{2}$ in. dia and $\frac{1}{4}$ in. thick are ground, lapped and placed in a container; a high pressure stem jet flowing from a $\frac{1}{16}$ in. orifice is allowed to impinge directly on the specimen and then spread out radially at high velocity through a restricted area, eroding and cutting the specimen as steam escapes through the exhaust to the atmosphere. The distance between the mouth of the orifice and the specimen is 0.005 in. and there are four exhausts each $\frac{1}{32}$ in. in dia. The relative erosion resistance of various stainless materials is given in Table II.

CHEMICAL STABILITY—The corrosion resistance of surface hardened parts also compares favorably with those of untreated parts, providing the process is correctly carried out. They will withstand the action of salt spray, salt water, alkaline solutions, caustics, steam, water, industrial atmospheres, crude oil, gasolene, kerosene, stack gas, propane, and butane. This has been confirmed both by service tests and by laboratory tests. However, case hardened stainless steel parts should not be used in contact with mineral acids.

FINISH—In some instances, the necessity of finish grinding conventionally hardened stainless steel has prevented the logical design and construction of equipment for economical reasons, and in other cases, the design had to be modified for physical reasons since unstable conditions resulted in the development of hair cracks, spalling, and warping during the finishing operation. Now stainless steel parts can be finish machined and ground to the tolerance necessary for mating surfaces in close contact prior to surface hardening. Formerly these requirements made impossible the manufacture of complicated and intricate parts that were difficult to hold to form during hardening and subsequent tempering, and rendered these parts useless unless a great amount of straightening was resorted to, with accompanying dangerous straining and probable early failure in service.

PHYSICAL PROPERTIES—Finally, physical properties are not seriously affected by the case hardening process. Reference to Table IV indicates that while the tensile strength, yield strength and impact strength may decrease slightly, the case hardness and fatigue strength increase considerably. In addition, the parts are free from internal stresses and, therefore, free from aging effects when in service.

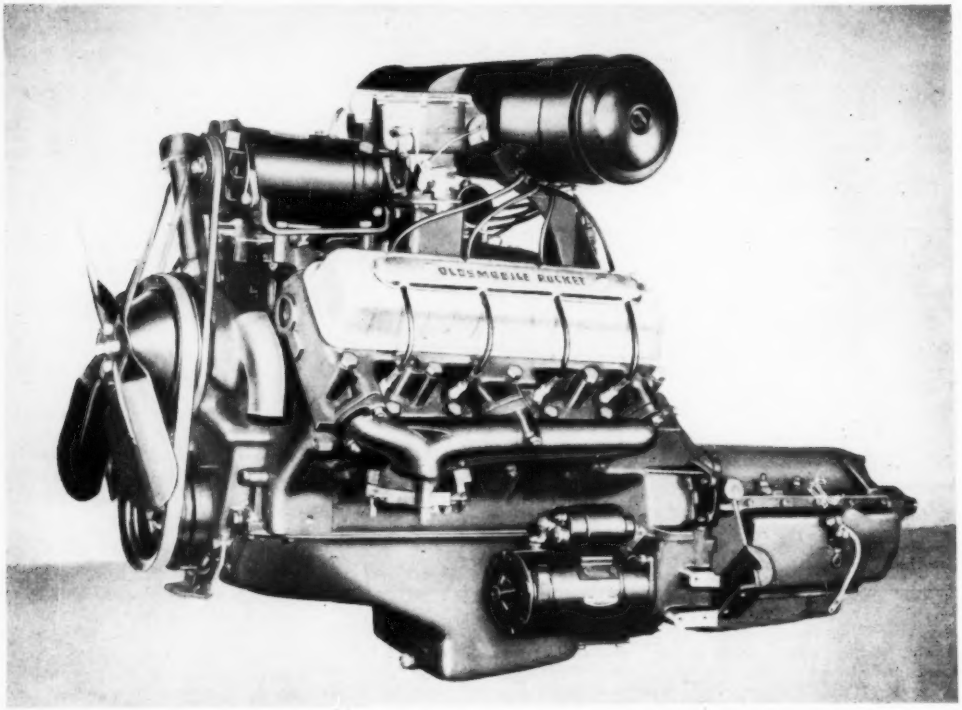
Applications of Hardened Parts

The first application of hardened stainless steel parts was in disks and seats of high temperature, high pressure valves. Since then, the applications have been extended to control valves, pistons, cylinders and guide bushings, valve stems and lifter valves for high pressure turbines, piston rods for high pressure refinery pumps, seat rings and disks for valves in oil refinery service, and many other parts of a similar nature.

In the aircraft industry, hardened stainless steels are applied to instruments and accessories that must have a low coefficient of friction, extreme dimensional accuracy, and that must operate at low temperatures where the bearing surfaces cannot be lubricated and where seizure is a major problem. The machine tool industry has applied the material in cams, gears, and other parts; and in the forge shop, case hardened stainless steel has increased the life of trimming dies, coining dies, and mandrels as much as 300 percent over parts made of other materials.

* * * *

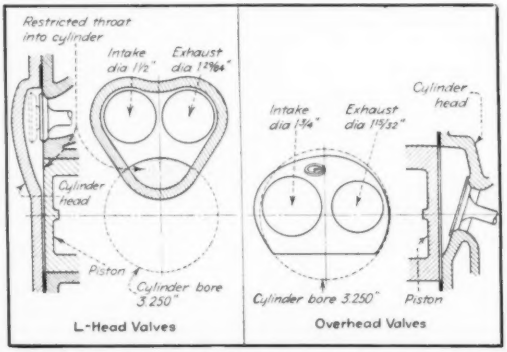
NO OTHER ARTICLE of widespread use contains so many different materials as today's automobiles, according to a recent tabulation by one industry scientist. Of the 96 known chemical elements, 35 are found in most of today's cars, and 44 are used in the making of automobiles. Some of the metals that go into making cars include aluminum, arsenic, beryllium, cobalt, copper, tungsten, uranium, gold, radium, platinum and silver.



ENTIRELY NEW, the 1949 Oldsmobile V-8 engine is the first production design of high compression engines in the General Motors Line. Features include overhead valves, hydraulic valve lifters, combined vacuum and fuel pump.

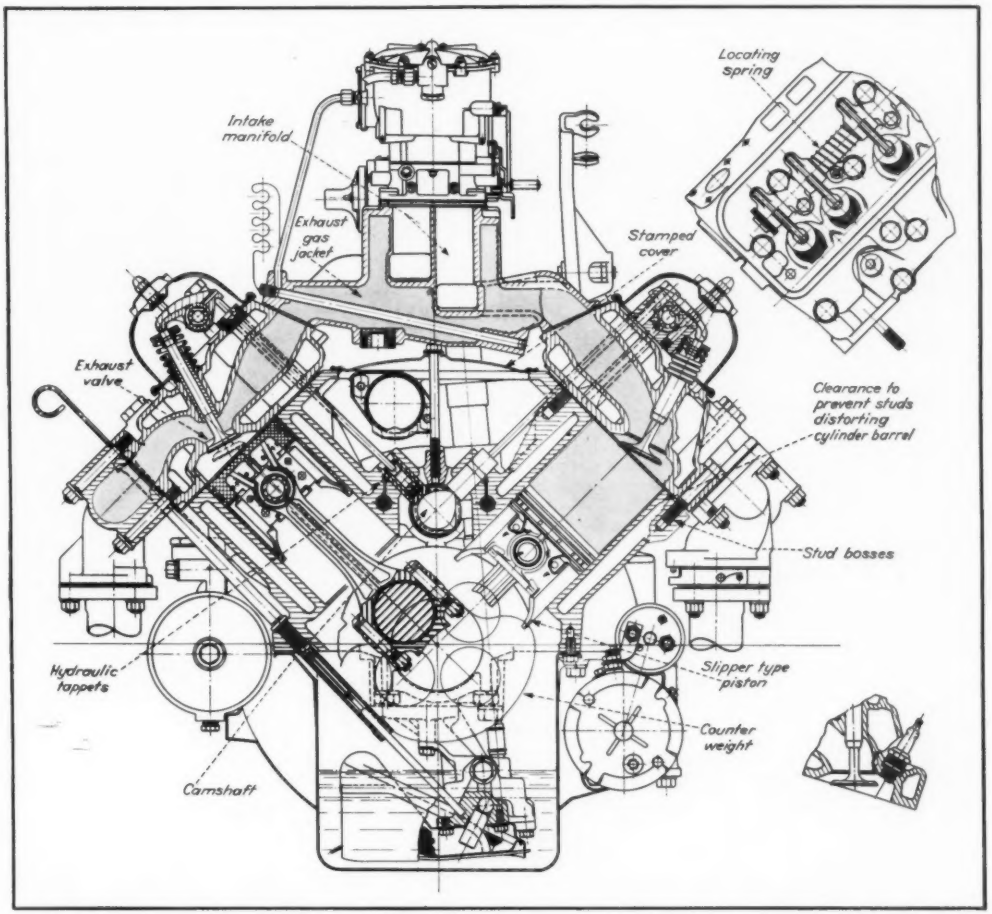
1949 Oldsmobile V-8 Engine

First commercial version of the high compression engine, conceived by Dr. Charles F. Kettering, former head of General Motors Research, will be used in 1949 Oldsmobiles. While the "Kettering engine" has a 12 to 1 compression ratio, that of the Oldsmobile engine will be only 7.25 to 1, the highest permissible with the fuels now generally available. Even with this limited increase in compression ratio, as compared to conventional engines of similar size, horsepower, 135, is 17 percent greater; maximum torque, 263 lb-ft, is 20.5 percent greater; thermal efficiency, 26 percent, is 18 percent higher. Specific fuel consumption has been decreased from 0.620 lb. per hp hr to 0.533 lb. per hp hr. The former Olds straight 8 had a stroke to bore ratio of 1.191, the new engine has a ratio of 0.917, with resulting 13 percent drop in piston speed.



WHY THE NEW ENGINE has overhead valves. L-Head construction restricts flow of gases and sizes of valves, which for high compression design gives low volumetric efficiency.

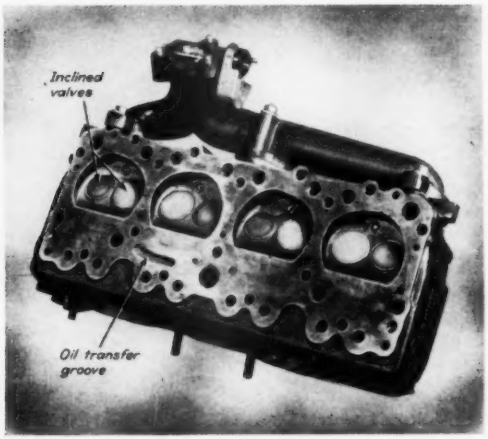
D E S I G N S



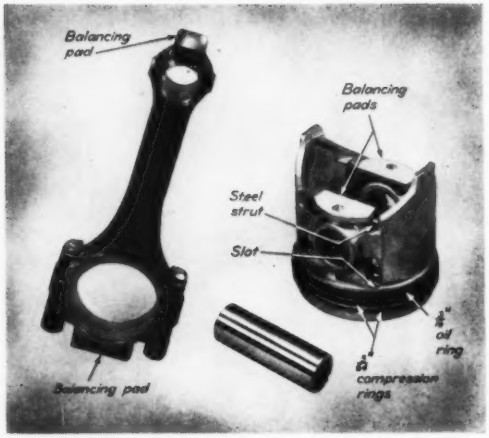
V-TYPE DESIGN gives a stiffer crankcase to resist the 1,000 psi explosion pressure, gives a shorter engine, only 33 1/16 in. overall, and also gives stiffer crankshaft. Cylinders are tied tightly where they come together in the valley, while the head ends can accommodate thermal expansion without restraint. Camshaft bearings are in the valley. To improve gas mixture flow and to shorten rocker arms, the valves are set at an angle. Hydraulic valve lifters maintain zero clearance between cam and follower at all times, giving silent action and automatically compensating for any changes in lengths of valve linkage elements caused by wear or expansion. Between cylinder banks there are openings in the valley through which oil splashes to lubricate portions of valve linkages and is cooled by water jacketed portions of lower cylinder walls. Passages from each exhaust valve port lead the hot exhaust gases to jacket around intake manifold. Most of the cylinder head stud bosses are completely outside the jacket wall, the centerline of the stud being three diameters or more from the inside wall of the cylinder. Where the stud comes within two diameters of the cylinder wall there is a clearance space between the boss and the cylinder wall. Thus there is no possibility of strains developed in tightening the studs being transmitted to the cylinder wall. Right cylinder bank is staggered $\frac{7}{8}$ in. to rear of left cylinders. This arrangement made it possible to design connecting rods so that they are symmetrical with the axis of the rods which passes through the mid point of the connecting rod bearing. At the head end the wristpin floats in both the rod and the piston. Offset oil passages feed each connecting rod bearing separately, introducing the oil in the lower pressure area of the bearing. Oil for tappets is supplied through longitudinal galleries connected to the crankshaft by passages in the transverse bulkheads. Main bearing caps are recessed $\frac{1}{4}$ in. into crankcase to assure alignment.

(*continued on next page*)

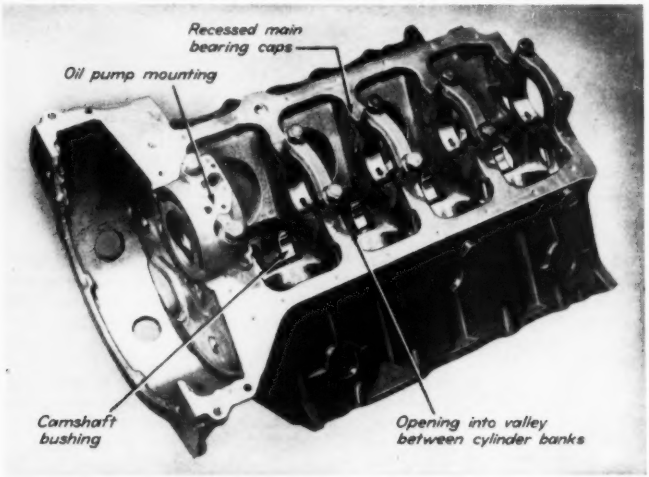
Oldsmobile Engine (continued)



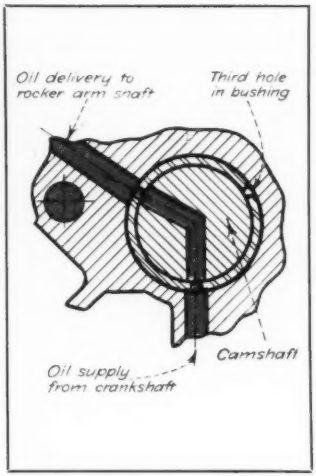
UNDERSIDE OF CYLINDER head showing groove through which lubricating oil flows from one section of the head to another at points where the passage in block and head does not align. The inclined valves improve the flow path, and allow shorter rocker arms thereby reducing inertia of the valve linkage system. Combustion chambers are "as cast" but all are made within 0.006 cu. in. of the same volume by registering the machining of face of head from the cavity surfaces, inspecting finished heads on Cavitometer instrument which measures cavity volumes, (see p. 93) and reworking the head if tolerances are exceeded.



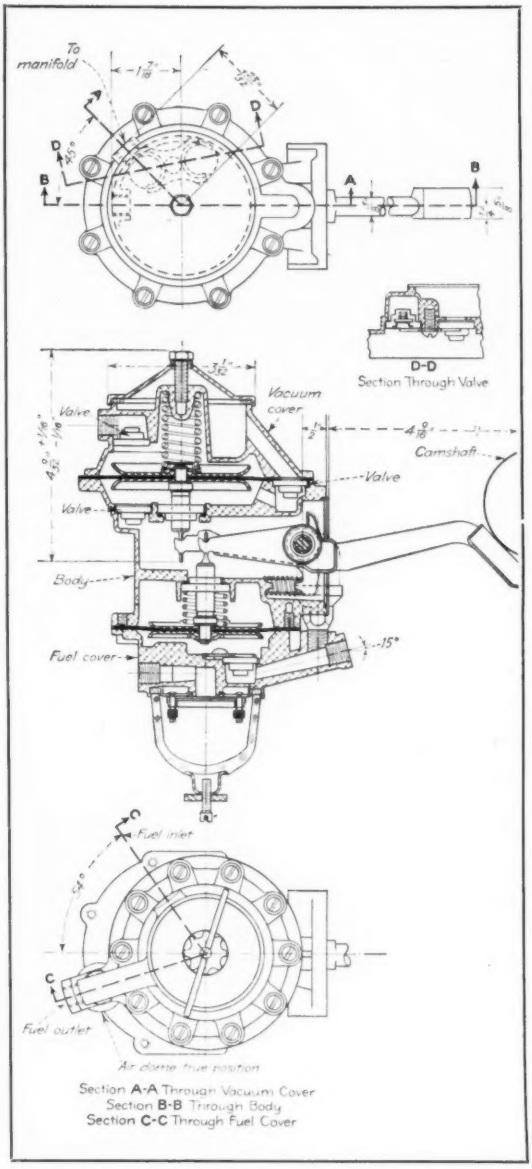
TOP AND BOTTOM BALANCING PADS on the rods are machined off in an automatic machine until the weights of the head end and the crank end are reduced to the figures specified, thereby obtaining a practically perfectly balanced rod. A similar operation is performed on all pistons, the weight of each piston being practically the same. The slots between the head and skirt of the slipper type piston lessen heat transfer to the skirt, thereby minimizing possible skirt distortions that would impair the proper fit of piston in cylinder. The steel struts give added support to the wrist-pin bushings.



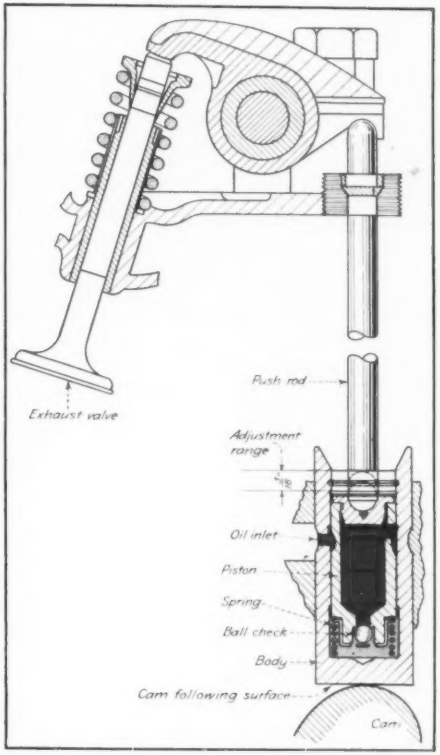
LOOKING INTO CRANKCASE from below. Here can be seen how the main bearing supporting bulkheads tie the two banks of the V together. The openings between the crankcase and the valley of the V are between the bulkheads. The camshaft bushings are tinplated on their outer surface to assure a full seating when they are press fitted into position. Recessing of the bearing caps and the dowelling of the rear bearing can be seen.



ROTATION OF CAMSHAFT meters the oil furnished to the rocker arm shaft. Camshaft bushing has three drilled holes spaced 120 deg and at mid length of the bushing, to assure fool-proof assembly.



COMBINATION VACUUM PUMP and fuel pump, both driven through rocker arms riding on an eccentric on the camshaft. A feature of the vacuum pump is that it is double acting and serves as a booster between the windshield wiper and the engine manifold. Additional vacuum is required to drive wiper at the increased slope of windshield. The pump is mounted on the timing chain case. The camshaft is driven off the crankshaft by a silent chain.



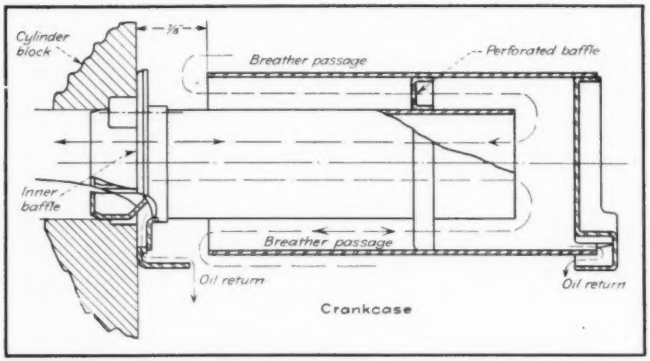
OPERATION OF HYDRAULIC VALVE LIFTER. Lubricating oil under pressure enters through body and into hollow piston, through ball check valve and thus into cylinder space between piston and body. Oil pressure plus spring develop enough force to take-up all slack and clearances in valve linkage system when valve is closed, but not enough force to lift valve. This is situation when cam following surface rides the base circle of cam. When cam nose begins lifting the body, ball check closes immediately. It has only a few thousandths travel. The trapped oil then acts as a solid and practically inelastic lock between body and piston which then ride the cam as an integral unit thus always opening and closing the valve exactly in accordance with the cam timing.

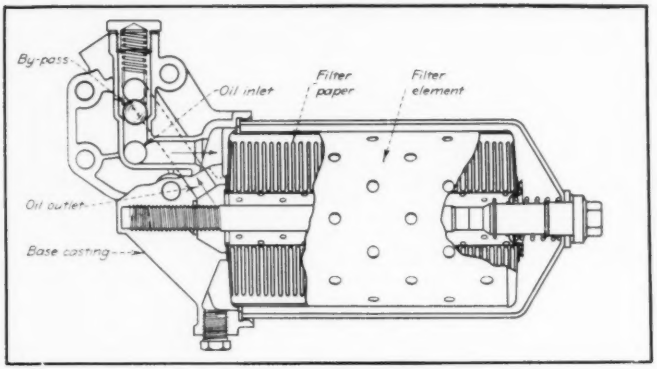
Thus at all times when the engine is running and the lubricating oil is under pressure the cam following surface is riding in contact with the cam. There can be no play or backlash and thermal expansions and wear will be compensated automatically. Hence there can be no impact as between tappet and cam in conventional designs, no variable clearance to contend with, and no noise. Nor is it possible to have negative clearance such as sometimes occurs in conventional tappets and burns out the valves.

Maximum range of automatic adjustment is $\frac{3}{16}$ in., this being considerably more than required over the life of the engine. (*continued on next page*)

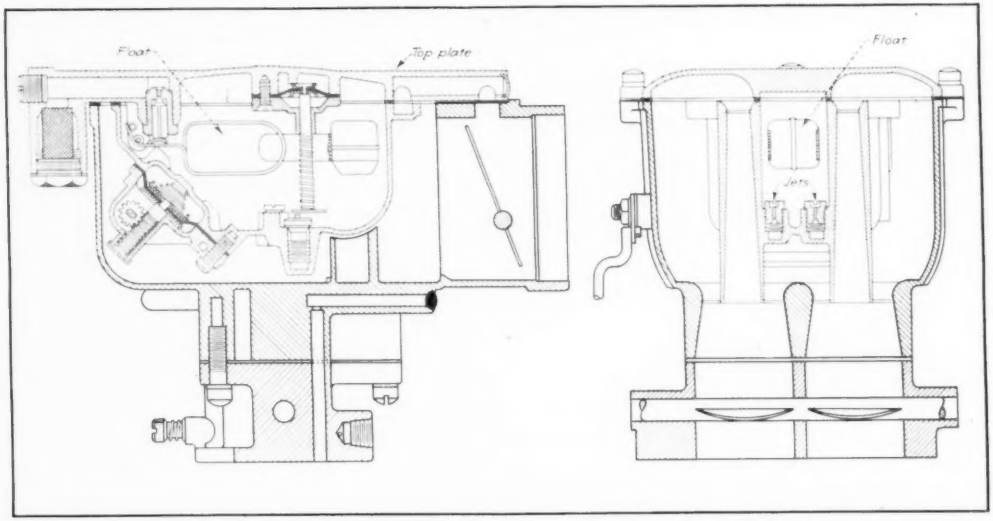
Oldsmobile Engine (continued)

CRANKCASE BREATHER is at the rear of the engine between the cylinder banks. Most of the oil vapor is taken out by the inner baffle assembly, the balance by the perforated baffle, and returned to the crankcase.





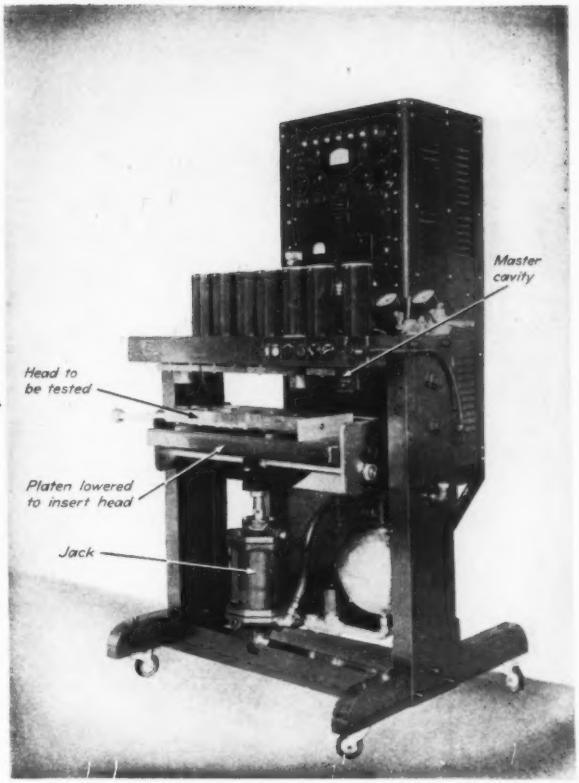
FULL FLOW A-C oil filter bolts directly to crankcase with no external piping. Accordion shaped resin-treated paper filter has filtering area sufficient to handle full flow with low pressure drop in a moderate size unit. Bypass valve opens at 5 to 7 psi pressure differential to take care of circulation while "warming up" engine in cold weather and also when filter replacement has been neglected.

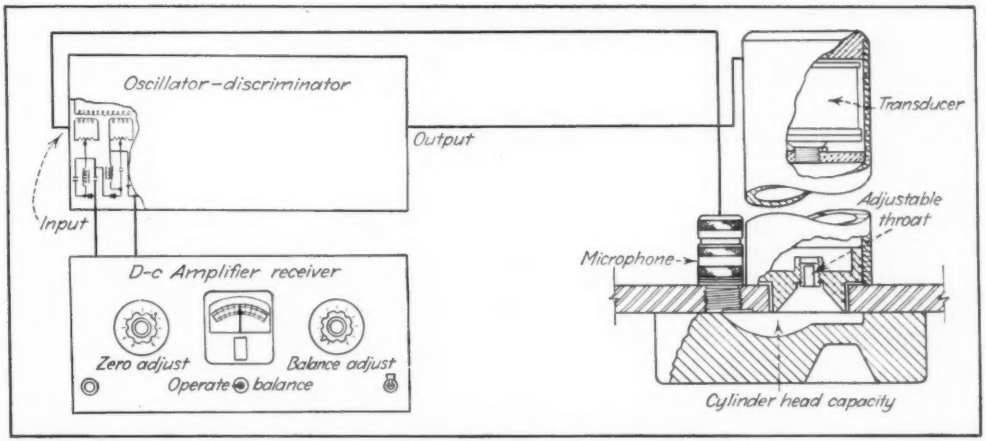


OPERATING ELEMENTS of dual carburetor (blue) are mounted on the inside of top plate. This greatly simplifies servicing the carburetor, which is done by removing the top plate and taking it over to the work bench. Liquid chambers are insulated from engine heat, the incoming air further cooling the chamber walls and reducing possibility of vapor lock. Dual jets are symmetrical and close to float to assure uniform gasoline feed.

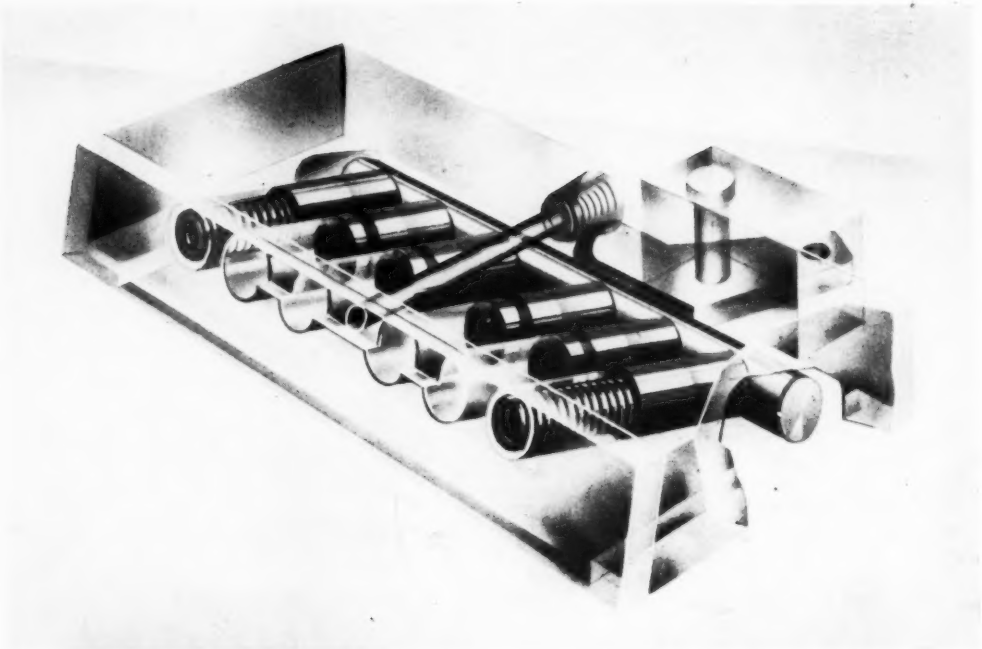
Cavity Resonance Measures Volume Changes

Comparison of the resonant frequency of vibration of air contained in a cylinder head cavity with that of a standard cavity, measures the volume of the cavity under test. The "Cavitometer" excites sonic vibrations in the two cavities being compared, determines the resonant frequencies by rise in output of microphones adjacent to the cavities, and compares the two frequencies in a discriminator circuit. If the difference exceeds preset tolerances, a signal is lighted, and the machine stops until the operator decides whether to accept or reject the casting. Instruments are made by Poole Engineering Co., Dallas, Texas. Machines may be built for four, six or eight cylinders. The cylindrical elements are sound absorbing housings for transducers which excite the vibrations. Standard head is at the extreme right. A jack clamps the head to be tested against a plate containing cavity throats, transducers and microphones.





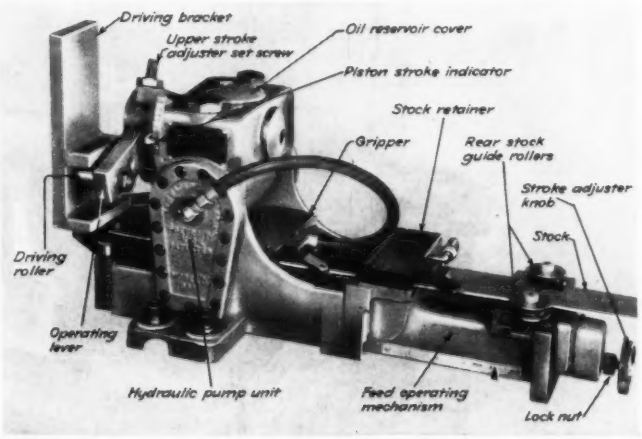
CLOSED OSCILLATORY SYSTEM operates at resonant sonic frequency of the cavity. Discriminator translates this resonant frequency into a direct current proportional to volume differential as compared with a master cavity. Comparison neutralizes changes in air temperatures or humidity. An electronic memory circuit may be added to hold any two cavities in a given head within certain limits, as well as holding all cavities within extreme limits.



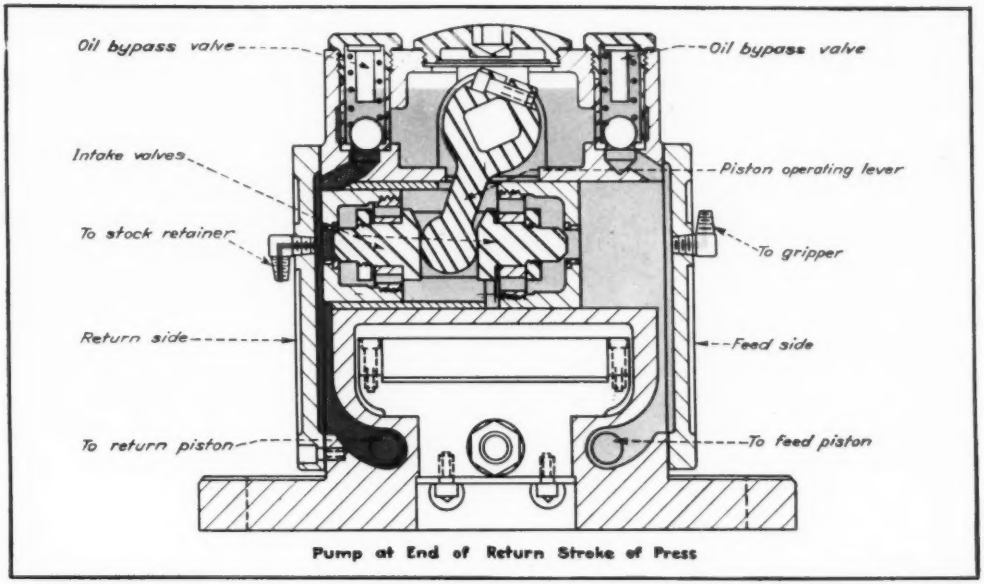
ON UP STROKE OF RAM, gripper engages stock and is moved forward by feed piston. On down stroke, stock retainer holds stock in position while piston returns gripper for next cycle. Bypass valves prevent excessive pressure.

Press Ram Actuates Hydraulic Feeder

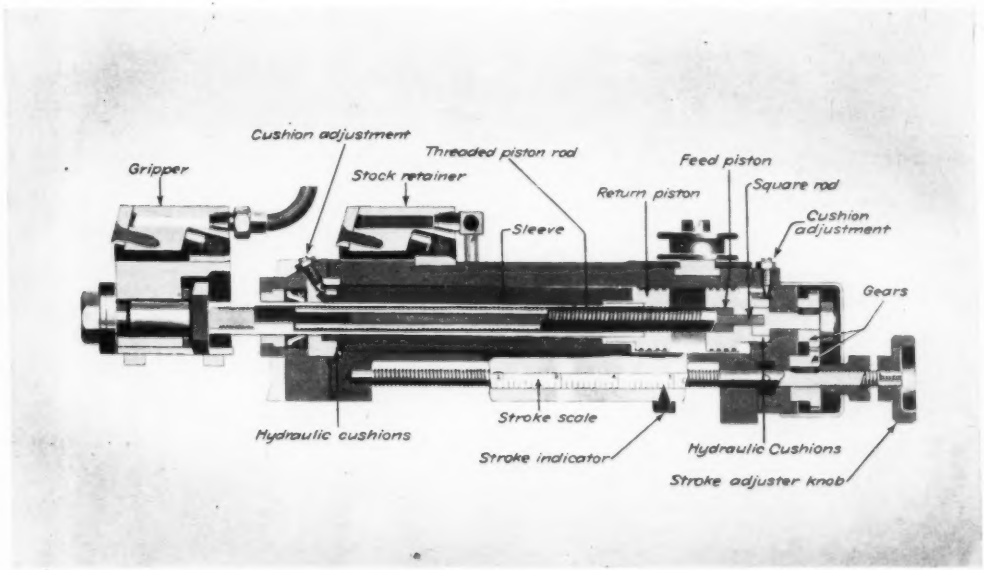
A double acting pump driven by the press ram provides oil pressure for operating gripper, stock retainer, and feed piston. Driving bracket, attached to press ram, operates double acting piston pump. Adjustment for length of press stroke relative to stock feed is provided by a series of holes in operating lever for driving roller and by adjustable lost motion device between lever and piston drive shaft. The unit made by Haller Machine and Manufacturing Co., Detroit, Mich., will feed strips up to 3/32 in. x 4 in. Stock advance can be set at any value between 0 and 5 in. per stroke. Larger models are powered by motor driven pump and controlled by a ram-actuated 4 way valve.



GRIPPER AND STOCK RETAINER contain 4 hydraulic clamping cylinders and 2 spring plungers to insure uniform initial contact of floating roller with stock. Roller engages cam surface to insure secure grip. A lever (not shown) lifts roller during set-up of mechanism.



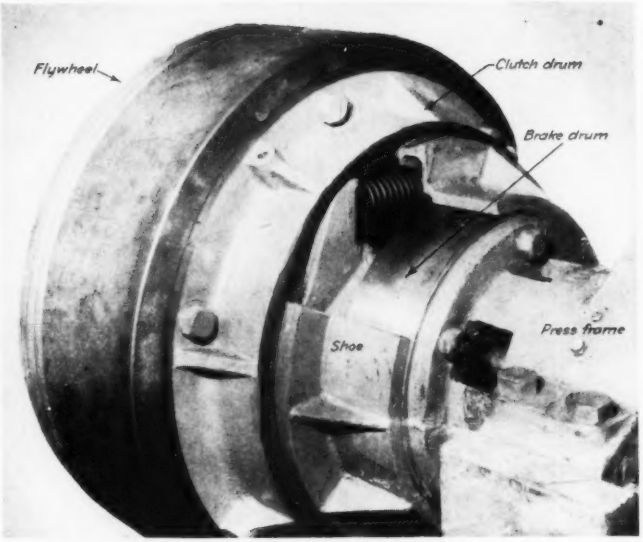
INITIAL MOVEMENT OF PISTON LEVER closes intake valve to trap oil in cylinder before piston begins its working stroke. Return side of power piston is smaller than feed side to compensate for volume of piston rod in feeding unit. To insure completion of cycle, piston travel is adjusted for slight flow through relief valves at ends of stroke.



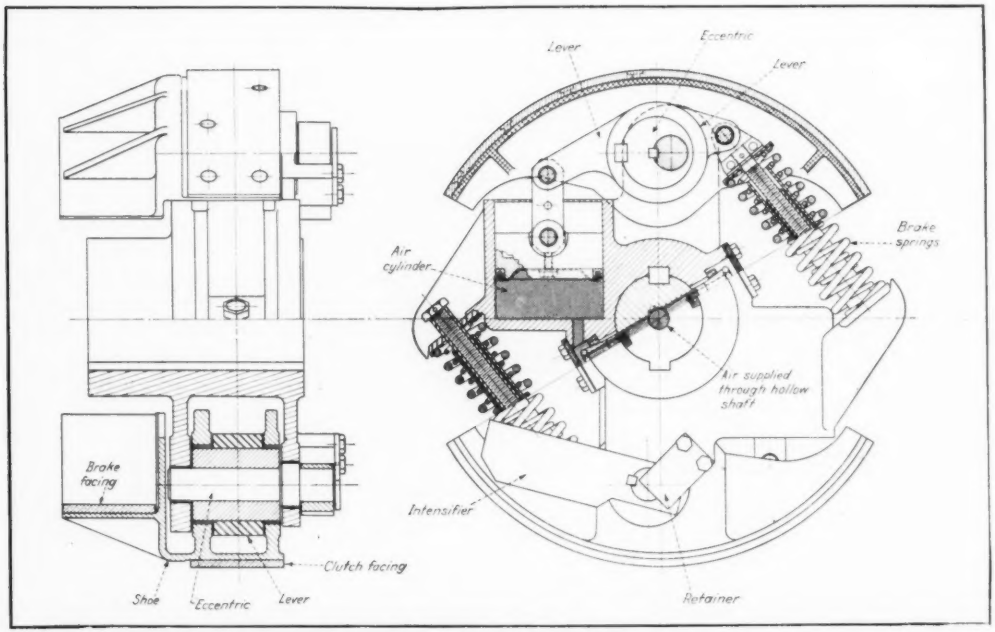
STROKE IS POSITIVELY LIMITED by contact of pistons with cylinder heads. Adjustable hydraulic cushions absorb shock at ends of piston movement. Length of stroke is determined by separation of pistons. Feed piston rod is threaded into non-rotatable return piston so the distance between pistons can be adjusted. Stroke adjuster accomplishes this through gearing to the square shaft which is engaged in a square hole in feed piston. The feed piston is brazed to piston rod. Threaded stem of stroke adjuster controls pointer position and stroke scale.

Combined Clutch and Brake For Presses

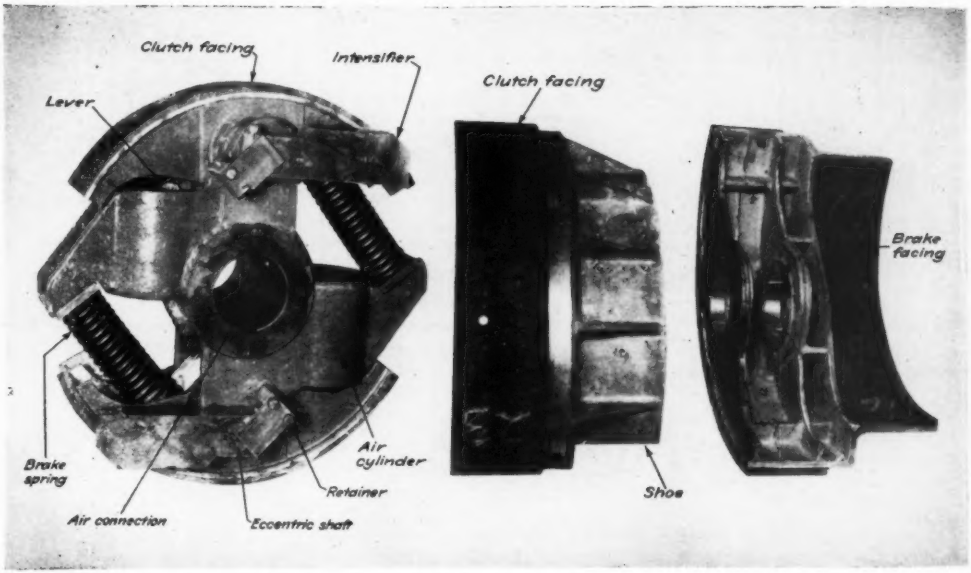
Clutch and brake facings are mounted on different parts of the same shoe so that simultaneous application of both is impossible. Excessive wear is thus avoided. The press can be protected against overload by reducing air pressure applied to the clutch so that it will slip at a selected load. Springs apply brake and act automatically in case of power or air-pressure failure. The Cleveland Punch and Shear Works Co., Cleveland, is the manufacturer.



CLUTCH AND BRAKE do not require adjustment for wear because range of movement of air pistons and springs is sufficient to maintain desired pressures in spite of changes in thickness of linings.



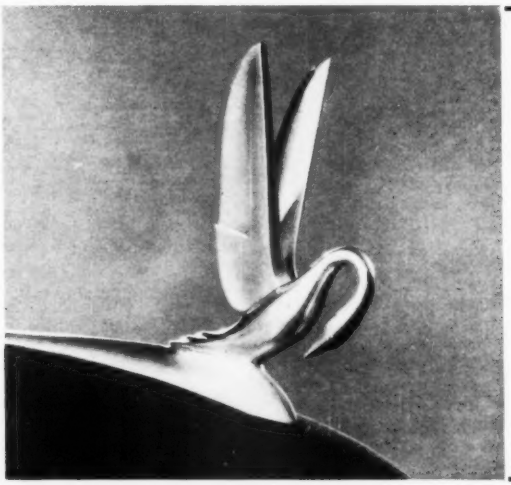
IN IDLE POSITION, spring rotates levers and eccentric shafts to contract shoes and hold brake lining against drum bolted to press frame. Compressed air, applied through hollow shaft, actuates air pistons to overcome springs. This rotates levers and eccentrics in opposite direction, expands shoes and forces clutch linings against drum on flywheel.

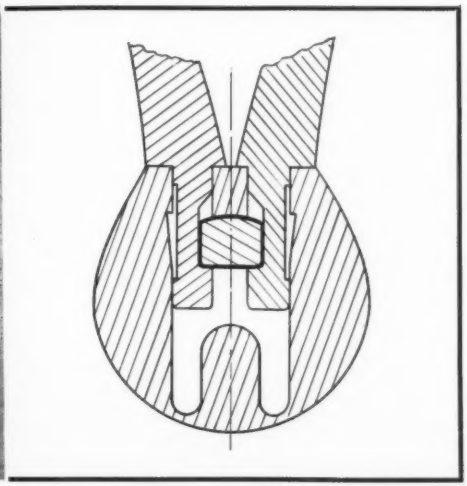


INTENSIFIERS, on flywheel side of clutch increase braking effect. When unit is revolving, centrifugal force acting on intensifier assists spring in applying brake. Action of intensifiers permits use of lighter springs. Clutch action is also improved because, with unit at rest, air cylinder need only overcome spring force to engage clutch. Aluminum alloy shoe casting radiates heat developed in operation. Shoes can be replaced without dismantling press.

Wedge Locks Die Cast Assembly

A DIE CAST WEDGE locks wings to body of Packard radiator ornament. Complete ornament was cast in 5 parts because of shape and size. Tenons on wings are relieved to concentrate bearing at points which will hold assembly rigid. Crowned wedge equalizes locking forces between wings. Two screws secure body to die cast base. Reinforcement for forward screw is continued up body to simplify coring by avoiding an undercut.





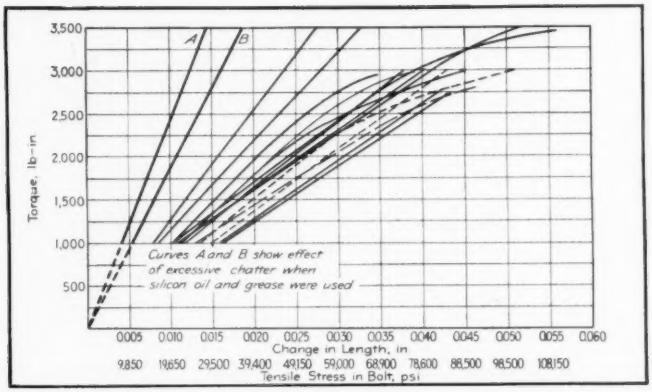


Fig. 1—Curves showing nut tightness or stud stretch plotted against applied torque for nut-stud combinations using various types of washers, lubricants and platings.

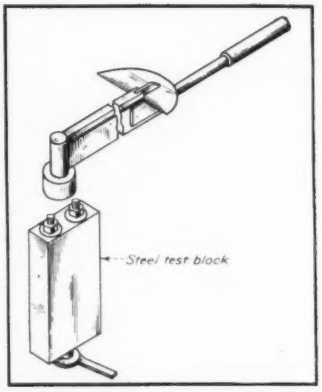


Fig. 2—Test method. The nut on the underside was held stationary.

Tightening Characteristics of Nut

- Conditions that prevent consistent tightening.
- Effect of thread lubricants and changes in washer material.
- Formulas for determining the torque load that is required to obtain desired tensile load in the stud or bolt.

WILLIAM F. PICKEL
Engineering Development Department
Allis-Chalmers Manufacturing Company

REASONABLY ACCURATE CONTROL of the tightness of bolted parts enables the designer to economize in bolt selection and assure safe bolt stresses. But two basic problems, bolt scatter and nut chatter, prevent consistent tightening even though the same torque value is applied to every nut.

Scatter refers to the deviation in stud stretch among identical bolts whose mating nuts are tightened to a given torque value under identical conditions. Curves in Fig. 1 illustrate typical variations in stud stretch, hence tightness, that occurs under different washer, lubricant and plating conditions. Chatter describes the phenomenon of certain nut and bolt combinations that assemble easily by hand, yet intermittently bind severely when tightened with a wrench. To learn what factors determine the consistency of bolt tightness, a research project was undertaken.

Consistent tightening of studs and nuts when torque wrench values are specified were found to depend on four items:

1. Condition of the thread surfaces.
2. Type of lubricant used.
3. Material of the two rubbing surfaces.
4. Condition of the nut face.

Equipment for the project consisted of 20 sample studs and nuts, a stud test block that simulated commutator clamp rings, special thread honing tools, various lubricants, washers of materials ranging from soft brass to hardened steel.

Torque wrench and test block used are shown in Fig. 2. A running log was kept of the tightening characteristics of each nut and stud combination, and extreme care was taken to record chatter when it occurred. After all values were recorded, the individual plots illustrated here were made of recorded torque at intervals for corresponding bolt elongations.

Thread Surface Test, Dry—No special operations other than routine cleaning of grit and chips were performed. Brass washers were used only to preserve the surface of the block and their effect upon the tightening characteristics was discounted as much as possible by information gained on their contribution in succeeding tests. Inspection of the resulting curves, Fig. 3(*A*), indicates more scatter and less stretch per torque value than shown in succeeding tests.

Some chatter exhibited in three of the nut-stud combinations may have been the result of dry thread surfaces in contact or may have been caused by the washers.

Lubrication Test—Five lubricants were used on both thread and washer surfaces in the hope of eliminating chatter and reducing scatter.

Filmite oil was used as a high pressure lubricant, while silicone oil and grease were tested to determine the stability of their lubricating properties after subjection to high temperatures. Graphite grease and ball bearing grease were tested because of their good lubricating properties at moderate temperatures and pressures.

Graphite grease proved to be the best lubricant. It provided smoothest tightening, Fig. 3(*B*), and resulted in a reduction in scatter and an increase in stud stretch per torque value. Brass washers were used again only to protect the test block surface. No chatter was experienced. Findings also indicate that chatter is less likely to occur as the stud stretch per torque value increases.

Results of tests with ball bearing grease are shown in Fig. 3(*C*). Slight increase in scatter over the graphite grease application and an average stretch per torque unit of slightly less occurred. There was little difference in ease of tightening provided by the two lubricants. Chatter occurred when two of the nut-stud combinations were tightened, but that may have been caused by the brass washers.

Hardened steel washers replaced brass washers on the Filmite oil test.

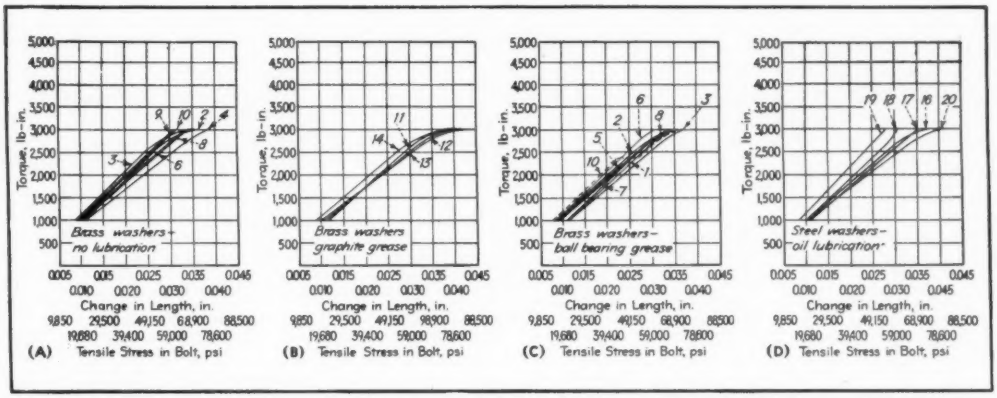

Torque, lb-in.
Change in Length, in.
Brass washers—no lubrication
Brass washers—graphite grease
Brass washers—ball bearing grease
Steel washers—oil lubrication
(A) Tensile Stress in Bolt, psi
(B) Tensile Stress in Bolt, psi
(C) Tensile Stress in Bolt, psi
(D) Tensile Stress in Bolt, psi

Fig. 3—Tightening characteristics of studs and nuts tightened: (A) without any lubrication; (B) when graphite grease was applied; (C) when ball bearing grease was applied; (D) when filmite oil was applied, using hardened steel washers.

and Stud Assemblies

Fig. 3*(D)*. Torque effort during tightening and stretch per torque value was about equal to that provided by ball bearing grease. Greater scatter was experienced, but that may have been caused by different stud and nut combinations or because hardened steel instead of brass washers were used. No chatter occurred.

Silicone oil and silicone grease were tested to determine their ability to withstand high temperature over an extended period of time without losing their lubricating quality. Both lubricants were a great disappointment. Each was generously applied to different thread and washer surfaces before subjecting the oiled and greased assemblies to high temperature. These nut-stud combinations were then tested for tightening quality. Excessive friction and chatter occurred.

As a check, silicone oil and grease were replaced alternately with graphite grease. No chatter occurred. A second test was made with the silicone again applied to the same mating nuts and studs. Again excessive friction and chatter made it impossible to accurately read the wrench scale. Average values of torque were read with some difficulty and plotted against corresponding stud elongations. Curves *A* and *B* of Fig. 1 show the results of using the two silicone oils and greases. Comparatively little stud stretch or nut tightening resulted from the effort spent in applying torque. Most of the torque applied was lost in supplying sufficient force to overcome excessive break-away friction, which greatly increased stud shear stress.

Curves in Fig. 3*(A)* where no lubricant was used, compared to any curves where washer and thread surfaces were lubricated, reveal that the use of a lubricant is not sufficiently advantageous to warrant its use.

Washer Test

Soft steel washers were tested first. The nuts were slightly harder than the washers. Tearing of the metal at the washer and nut surfaces was observed after the first tightening. Both surfaces showed rather deep gouging of the metal, not the usual wear of one surface against the other. Little chatter was noticed during initial torquing, but as the nuts neared required tightness, chatter set in and became progressively worse on consecutive tightenings. These results discourage the use of soft steel washers under soft steel nuts when loads are heavy. But these washers may be used under nuts lightly loaded because required tightness is reached before sufficient surface wear occurs to produce chatter. Lubrication does not noticeably reduce surface wear for this combination.

Hardened steel washers were tested and the results were favorable. No washer wear was visible, and the loaded surfaces of the nuts showed more uniform and less wear than when similar nuts were tightened against soft steel washers. The hardened steel washers were $\frac{1}{16}$ in. thick and heat-treated to provide a hard wear resistant surface. No chatter occurred. A comparison of dry and lubricated applications is shown in Fig. 4. The curves show a tendency toward greater uniformity when lubrication was not applied.

Brass washers approximately $\frac{1}{16}$ in. thick were tested with and without lubrication. When bearing the nut load the soft brass washers scored deeply, the soft steel nuts showed no wear. Chatter did not result initially

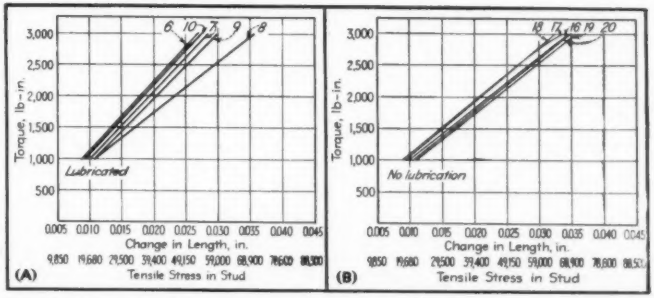


Fig. 4 (A)—Tightening characteristics when surface hardened steel washers were used with lubrication; (B) using surface hardened steel washers without lubrication.

from the metals used, but the nuts picked up brass after consecutive tightenings. Far worse, the softness of the washer material and the heavy nut loads caused the washers to dish badly. Top surfaces of the washers raised and locked against the hexagonal corners of the nuts. Dishing of the washers caused them to lock against the stud threads. Thus the nuts were locked to the washers and the washer ID was reduced to lock on the stud threads. As torque was applied the entire assembly tried to turn with the wrench and an exceedingly large shear stress was set up in the stud shank. As torque was applied to the nut, one of the locked surfaces broke loose momentarily, only to lock again when the end of the torquing stroke neared. This caused excessive chatter and made torque wrench scale readings next to impossible.

Findings of tests favor the use of hardened steel washers with soft steel nuts for heavy loads. Brass washers, preferably as thick as possible, are suitable for light loads. Size and type of washers did not seem to have much effect on scatter, but correct washer selection materially reduced chatter and binding.

Contacting Surfaces Silver Plated

Stud threads, nut threads, and nut bearing surfaces were silver plated in belief that silver would have maximum lubrication properties. When a plated surface was turned against an unplated surface, a two-fold favorable condition was brought about: (1) Dissimilar surface metals were in rubbing contact, resulting in minimum friction and (2) silver acted as a lubricant under the high pressures during tightening.

The silver plating tests may be divided into three parts: (1) Plated stud threads were tightened against unplated nuts, (2) plated nuts were tightened against unplated stud threads, and (3) plated nuts and plated stud threads were tightened one against the other.

Characteristics of plated stud threads and nuts not plated are illustrated in Fig. 5(*A*). This combination offered no advantage.

Exceptionally good results, Fig. 5(*B*), were obtained when plated nuts were tightened against unplated stud threads. Tightening the well cut stud threads against smoothly plated nut surfaces resulted in two smooth surfaces, one hard and the other soft, turning under heavily loaded rubbing contact.

Results obtained when both plated nut and plated stud threads were tightened together are plotted in Fig. 5(*C*). Curves indicate excessive scatter. Tightening produced tearing on both of the plated surfaces. This unfavorable surface condition had been anticipated since both surfaces were soft and one did not provide a hard, wear-resistant surface for the other. Thus, when two surfaces are in rubbing contact, and one of them is to be plated, best results can be obtained by plating the rougher of the two and letting the other surface act as the hard, wear-resistant facing.

It is recommended that only nuts which have clean, smooth threads, sufficient and parallel bearing areas, and bearing surface relief to prevent nut-washer locking be used. Chatter occurred when irregular nuts having overhanging hexagonal corners were used with brass washers. When hardened steel washers were used, however, no chatter was noticed, regardless of whether or not nut hexagonal corners extended below the bearing surface. Hardened steel washers are recommended for use under nuts heavily loaded. Nuts lightly loaded may be supported by comparatively thicker brass washers.

The condition of the threads on both nuts and studs contributes more to scatter than to chatter. Improved methods of thread cutting, possibly with the addition of a fine silver plate to the rougher bearing surface, would provide greater tightening consistency and increase reliability of tightness measured in terms of torque. Oil and grease, even high pressure types, on threads and washers do not noticeably reduce scatter and chatter.

Optimum conditions for practical uniformity of torque tightening are obtained when hardened steel washers are used and mating threads are ground smooth. Then lubrication is not necessary.

Computing Total Stress

One of the significant factors of these tests was the derivation and use of two equations indicating total stud stress in terms of the measurable tensile stress. Total stud stress must be known before it is possible to know the proximity of the stud stress to the yield point.

Two equations were derived to indicate the amount of total stress which might reasonably be expected to exist in a stud during smooth, consistent tightening. This total stress was expressed as a percent of the tensile stress, which was easily calculated. Similar calculations were then made for a number of different stud sizes. Results indicate that for a ¾ in. nut and stud which tighten together smoothly without binding and chatter, the total stress which might reasonably be expected was approximately 25 percent greater than the tensile stress.

Symbols used in these equations are

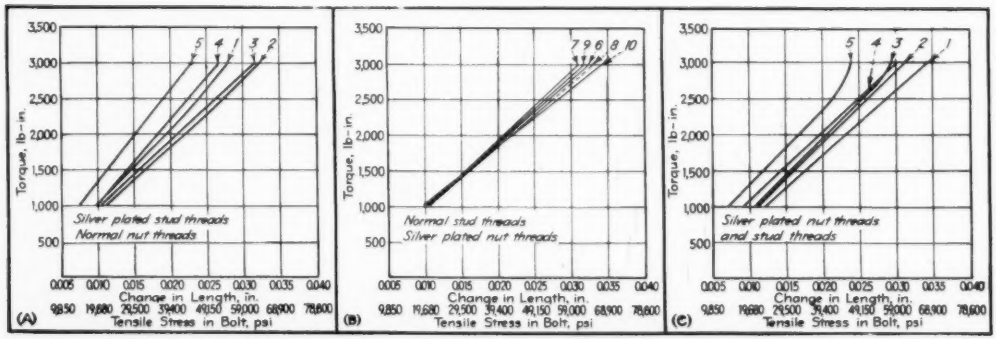


Fig. 5 (A)—Tightening characteristics when smooth stud threads were silver plated and tightened against comparatively rough and unplated nut surfaces; (B) when rough nut thread surfaces were silver plated and tightened against smooth unplated stud threads; (C) nuts and stud threads both plated. This procedure causes excessive scatter and is not advisable.

listed below, and Fig. 6 shows their relationships.

Symbols

P = axial force on nut, stud or washer, lb
β = angle of rise of the mean helix, deg
α = half the thread profile angle, 30 deg
ϕ = friction angle, the tangent of which is μ deg
F = force on the nut, lb
W = total work, in.-lb
W_{th} = work done against thread friction, in.-lb
T_1 = that part of the torque which overcomes thread friction and produces the shearing action on the stud, in.-lb
T = total torque used to overcome thread friction plus washer-nut friction, in.-lb
S_s = shearing stress in stud, psi
S_t = tensile stress in stud, psi
d_p = pitch diameter of stud thread, in.
d_r = root diameter of stud thread, in.
C = $d_r/2$
μ = coefficient of friction on threads
f = coefficient of friction between washer and nut
N = partial normal force to thread surface but parallel to axis of stud, lb
N = $P/\cos\alpha$, lb
D = distance traveled by friction force (F') along the mean helix of the thread surface, in.
F' = force of friction along the thread surface, lb
m = $\tan(\beta+\phi)/\cos\alpha$
d = mean diameter of the bearing surface of the nut, in.
e = total stud elongation, in.
l_w = stud working length, in.
E = modulus of elasticity, psi
a = area of stud shank or thread root area, whichever is smaller, sq in.
A = total stud stress, psi
p = load of the thread, in.
d_n = nominal stud diameter, in.

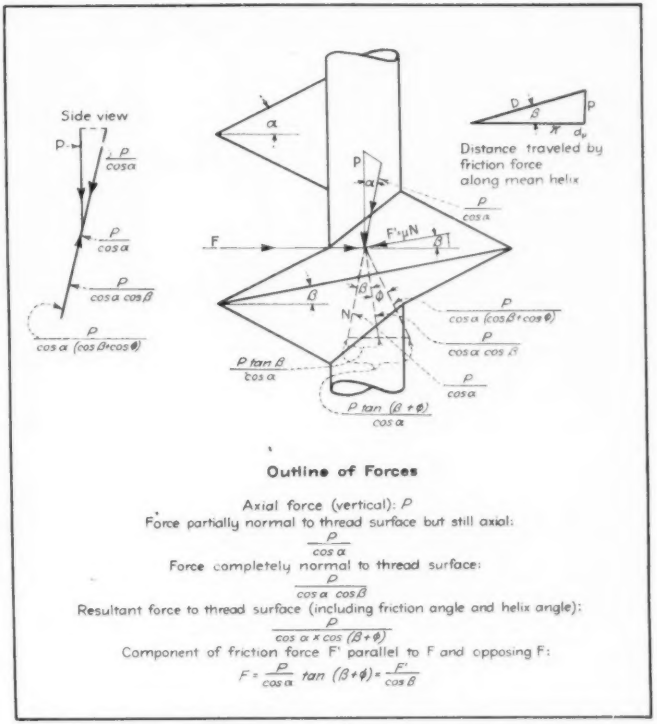

Side view
Distance traveled by friction force along mean helix
Outline of Forces
Axial force (vertical): P
Force partially normal to thread surface but still axial:
Force completely normal to thread surface:
Resultant force to thread surface (including friction angle and helix angle):
Component of friction force F' parallel to F and opposing F:

Fig. 6—Showing forces involved in deriving the torque equations given in the text.

The first equation to be derived expresses the ratio of the shear stress in the stud during tightening to the stud tensile stress in terms of stud angles and diameters.

The second equation to be derived expresses the ratio of the axial stud load P, created by the tightened nut, to the total torque supplied by the wrench.

The assumptions forming the basis of the following derivations are as follows:

1. Total torque T was the sum of the torque to overcome thread friction plus the torque required to turn the nut surface against the washer surface.
2. The equations expressed represent instantaneous values comparable to equilibrium conditions.
3. Washer remains stationary as the nut is tightened.
4. Force P is proportional to the increase in stud length.

Deriving Equation (1)

Work required to raise the nut on the stud thread in one revolution:

$$W_{th} = F'D$$

$$F = \frac{F'}{\cos\beta}$$

$$F = \frac{P\tan(\beta+\phi)}{\cos\alpha} \quad \text{Let } m = \frac{\tan(\beta+\phi)}{\cos\alpha}$$

$$F' = mP\cos\beta$$

$$D = \frac{\pi d_p}{\cos\beta}$$

Substituting for F' and D:

$$W_{th} = m\pi P d_p$$

Converting W_{th} to T_1:

$$T_1 = \frac{mPd_p}{2}$$

$$S_s = \frac{16\,T_1}{\pi d_r^3}$$

Substituting for T_1:

$$S_s = \frac{8\,m\,P\,d_p}{\pi d_r^3}$$

$$S_t = \frac{P}{A} = \frac{4\,P}{\pi d_r^2}$$

$$\frac{S_s}{S_t} = \frac{2\,m\,d_p}{d_r} \qquad (1)$$

Notice that only that part of the total torque which produces shearing in the stud was considered in the above derivation. The above formula, therefore, can be used for finding S_s or S_t but it may not take substitutions for finding the total torque T.

Deriving Equation (2)

The total work performed in turning a nut through one revolution is equal to the work to overcome thread friction plus the work to overcome washer friction.

$$W = W_{th} + W_w = mP\pi d_p + F\pi Pd$$

Converting work to torque; W to T

$$T = \frac{W}{2\pi} = \frac{mP\pi d_p}{2\pi} + \frac{F\pi Pd}{2\pi}$$

$$\frac{P}{T} = \frac{2}{(md_p + Fd)} \qquad (2)$$

(See Product Engineering, November 1943, pp 752-754, for torque-stress-load relationships in bolts and screws.)

The total torque T given above includes the stud shearing stress plus the shearing action of the nut against the washer and thus Equation 2 may be used for finding T or the axial force P, but it may not take substitutions for determining S_s.

Eqs (1) and (2) were used for finding total stud stress as follows:

The load P caused by the nut being tight on the stud was determined from the following equation by establish-

Table I—Friction Coefficients

Minimum	Mean	Maximum
$\mu = 0.12$ $V = 0.14$	$\mu = 0.14$ $V = 0.16$	$\mu = 0.16$ $V = 0.18$

ing a suitable stud elongation e, based on the proximity to the yield strength of the stud material.

$$P = \frac{EAe}{l_w} \tag{3}$$

Three values of P/T were calculated next from Eq (2), each corresponding to one of the three sets of friction coefficients given in Table I.

Knowing P from Eq (3), three values of T were calculated to correspond to the minimum, mean and maximum coefficients. The tensile stress in the stud was calculated next from:

$$S_t = \frac{Ee}{l_w} \tag{4}$$

The same value of e was used from Eq (3). All of the test data accumulated from all of the tests above were next plotted on one sheet, see Fig. 1, and an average torque was established. This average torque, from the average torque curves corresponding to S_t from Eq (4) and which represented test data, was compared to the three torque values calculated from Eq (2) and a favorable comparison of torques thus identified the most favorable friction coefficients. The mean coefficients turned out to be most suitable. It was then possible to calculate from Eq (1) the ratio of the stud shear stress to the tensile stress. This ratio substituted into the equation for total stress, Eq (5), based on the maximum strain theory, determined the total stress existing in the stud in terms of the tensile stress.

$$S' = \left[0.35 + 0.65\sqrt{1 + \left(\frac{2S_s}{S_t}\right)^2}\right]S_t \tag{5}$$

The quantity in the brackets was the coefficient for the tensile stress S_t. For a ¾ in. dia stud, the coefficient for S_t was 1.251, which indicated the total stress S' exceeded the tensile stud stress by 25 percent. The actual total stud stress existing in the stud during tightening corresponding to a stud elongation e is obtained by combining the two Eqs (4) and (5). Example: Consider a ¾ in. stud whose shank diameter was cut down to equal the root diameter of the threads on each end. A high grade steel was selected for the stud whose working length was 15¼ in. and root diameter sufficient to provide a shank area of 0.302 sq in. The stud was to be stressed until an elastic elongation of 0.025 in. resulted.

Calculate the total stress in the stud resulting from smooth, consistent torquing.

Stud load:

$$P = \frac{EAe}{l_w} =$$

$$\frac{30{,}000{,}000 \times 0.302 \times 0.025}{15.25} = 14{,}850 \text{ lb}$$

Calculate m:

$$m = \frac{\tan(\beta + \phi)}{\cos\alpha}$$

$$m = \frac{\tan(2.66 \text{ deg} + 7.96 \text{ deg})}{\cos 30 \text{ deg}} = 0.2162$$

$$\tan\beta = \frac{0.1}{2.155};\ \beta = 2.66 \text{ deg}$$

$$\tan\phi = 0.14;\ \phi = 7.96 \text{ deg}$$

Calculate T for comparison with established torque-stress curves using mean coefficients:

$$\frac{P}{T} = \frac{2}{md_p + Vd} \qquad T = \frac{P}{2}(md_p + Vd)$$

$$T = \frac{14{,}850}{2} \times$$

$$(0.2162 \times 0.685 + 0.16 \times 1) =$$

$$2{,}290 \text{ lb in.}$$

Calculate the stud tensile stress:

$$St = \frac{EA}{l_w} =$$

$$\frac{30{,}000{,}000 \times 0.025}{15.25} = 49{,}200 \text{ psi}$$

Compare the above calculated torque with the torque-stress test curves, Fig. 1, corresponding to the above tensile stress S_t. Favorable comparison establishes the mean coefficients to have been the proper choice. Calculate the ratio of the shear stress S_s to the tensile stress S_t:

$$\frac{S_s}{S_t} = \frac{2md_p}{d_r};$$

$$\frac{S_s}{S_t} = \frac{2 \times 0.2162 \times 0.685}{0.620} = 0.48$$

Calculate the total stud stress S' based on the maximum strain theory.

$$S' = \left[0.35 + 0.65\sqrt{1 + \left[2\frac{S_s}{S_t}\right]^2}\right]S_t$$

$$S' = [0.35 + 0.65\sqrt{1 + (2 \times 0.48)^2}]\,S_t$$
$$= 1.251 \times S_t$$

$$S' = 1.251 \times 49{,}200 = 61{,}600 \text{ psi}$$

Table II indicates, a small reduction in the ratio of total stress to tensile stress as the diameter of the stud increases.

Knowledge of the magnitude of this total stress, in terms of tensile stress, enables designers to specify maximum torque predicated to a tensile stress safely (25 percent) below the yield strength of the stud material.

A simple but convenient formula involving the nominal stud diameter, d_n, the nut clamping force P and a constant, 0.21 may be assembled into equation form. The formula expresses the torque to be applied to a nut tightened on a stud to provide a load P on the machine part:

$$T = 0.21 \times d_n \times P \tag{6}$$

Good Torque Application Practice

1. Conservative results from tests indicate studs may be tightened in tension to 75 or 80 percent of the yield strength for ¾ in. and larger studs.

2. Nuts properly tightened should apply a tension load to the stud equal to or slightly greater than the external load to be supported in service. Studs then cannot fail in service because the size was determined to safely carry the load, and nuts were tightened sufficiently to carry the greatest operating load.

3. Nuts insufficiently tightened below the operating load permit elastic or inelastic elongation of the stud. If inelastic, the stud fails immediately. If elastic elongation occurs, the stud may be good for many thousands of cycles of applied load. If, however, nuts are tightened to equal or slightly exceed the external load, each stud elongation under applied load is extremely small and stud life will exceed expected machine life.

4. During cyclic loads, the cyclic stress in studs increases as the elasticity of the bolted members decreases. Therefore, studs properly tightened against aluminum shoulders will be weaker than when tightened against steel shoulders.

a. Intermediate material of greater elasticity strengthens stud assembles.

b. Smaller nut bearing area weakens stud assembles.

c. Increasing the number of pieces assembled weakens studs. Stud weakness is caused by bending stresses caused by imperfect machining of mating faces.

d. Longer studs generally last longer than shorter studs.

5. Minimum thickness of thread plating provide best results.

6. Minimum clearance between stud and hole give best results.

Table II—Total Stress Relative to Tensile Stress

Stud Diameter in Inches	Total Stress in Percent of Tensile Stress
3/4	125.1
7/8	124.1
1	124
1 1/8	124
1 1/4	122.6
1 3/8	123.1

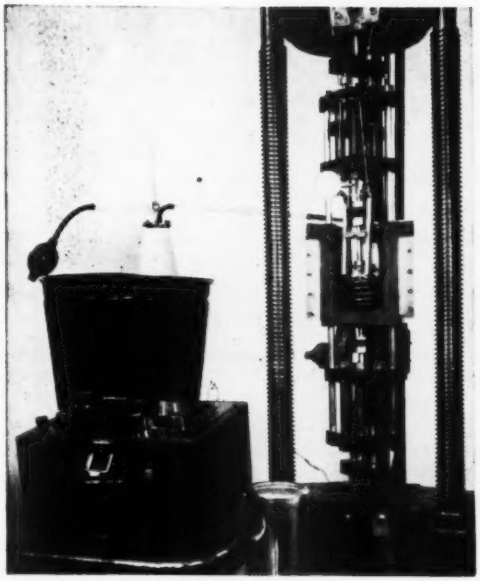


Fig. 1—Low temperature equipment, with front of insulated flask removed. Liquid nitrogen container is behind potentiometer.

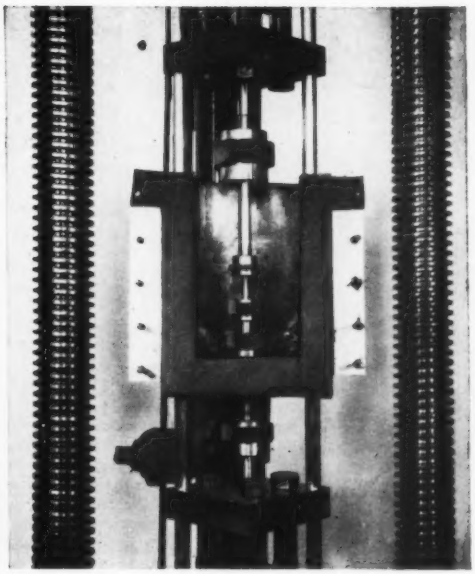


Fig. 2—Close-up of insulated flask and loading members. At extremely low temperatures, refrigerating coils are not used.

Apparatus for Tensile Testing At Sub-Zero Temperatures

An apparatus for tensile testing of metals at sub-zero temperatures designed to be used in conjunction with a special fixture to produce a maximum eccentricity of less than 0.002 in. in loading.

E. J. RIPLING and G. TUER
Metals Research Laboratory, Case Institute of Technology

LOW TEMPERATURE mechanical properties of metals have in recent years attracted a considerable amount of attention. This interest in low temperature mechanical behavior has been shown by investigators interested in commercial problems as well as those interested in more fundamental problems. The commercial interest in low temperature behavior arises from the fact that many commercial uses for metals, such as liquid gas storage and high altitude flying, depend directly on the low temperature behavior of metals. Consequently a large amount of data on the mechanical properties of metals, down to very low temperatures, has already been collected.

Interest in sub-zero temperature behavior from the standpoint of more fundamental investigation is somewhat newer, but at present many are of the opinion that some of the complex high temperature problems might be attacked by first studying the more simple phenomena that occur at sub-zero temperatures. Investigations conducted in the range where all temperatures are low enough to prevent diffusion make it possible to isolate the direct effects of temperature without the additional complications of physico-chemical changes that are inherent in high temperature work. Sub-zero temperatures are also being applied as a convenient embrittling agent, in testing of certain metals to obtain fracturing at small strains.

Because of the great importance of the mechanical properties of metals at low temperatures, an apparatus for conducting low temperature tensile tests has recently been designed and built at Case Institute of Technology. To keep the equipment comparatively simple, it was limited to tensile testing because this is the most general method of evaluating the strength properties of a metal, and is also generally considered the most lucrative mechanical test.

In designing the equipment care was taken to eliminate all sources of scatter that have their origin in the testing equipment and technique, thus reducing the number of tests necessary in each series to a minimum. Since most structural metals become brittle at sufficiently low temperatures, the mechanical properties under these conditions, as measured by a tensile test, are greatly affected by slight deviations from concentric loading. This is particularly true in determining the fracturing characteristics of these brittle materials since even slight eccentricity (or noncoincidence of the loading and specimen axes), if uncontrolled, produces a large amount of scattering.

To obtain maximum concentricity,

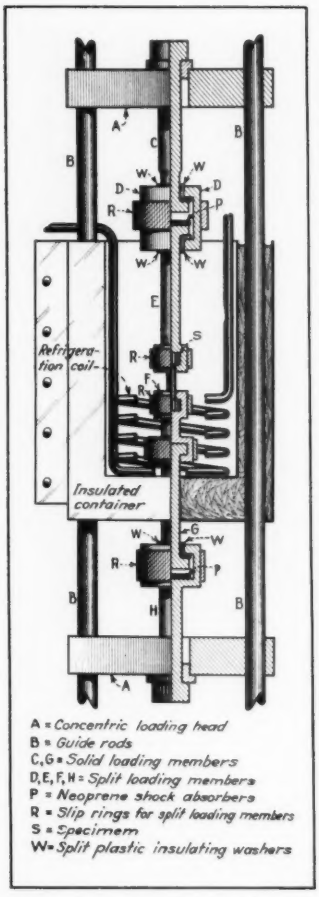


Fig. 3—Loading members, refrigeration coil and insulated flask, in half-section.

the apparatus was designed to be used with a specially-built concentric tension testing fixture. (See G. Sachs, J. D. Lubahn, and L. J. Ebert, "Notched Bar Tensile Test Characteristics of Heat Treated Low Alloy Steel," *Trans.*, ASM Vol. 33, 1944, p. 340-395.) Earlier tests indicated that this equipment produced an eccentricity of loading of less than 0.001 in.—that is, the distance between the specimen axis and the loading axis was always less than 0.001 inch.

The method of loading used in the low temperature tests is shown in Figs. 1 to 3. The load is transmitted through all the parts by buttonhead ends which avoid eccentricities caused by threaded joints.

To allow for easy assembly and disassembly of these buttonhead-ended parts, it was necessary to design some of the members split. Fig. 3 shows how these members fit together. All split members are held together by tapered slip rings. Buttonhead end loading members were ground to size on the cylindrical surface, to fit snugly with adjacent split members. Surfaces under the heads were ground to planes perpendicular to the cylindrical surfaces.

The main mass of the loading members are separated from the specimen, as shown in Fig. 3, by large insulating joints. These insulated joints allowed the specimen to be held at the temperature of liquid nitrogen while the loading members furthest from the joints are still not much lower than room temperature.

At "intermediately" low temperatures (—20 to —40 C), load was transmitted through the insulating joints by means of steel washers, since the length of the loading members was found to be sufficient insulation. At lower temperatures, the steel washers were replaced with thermosetting plastic laminate washers. However, because of the greatly reduced impact strength of the plastic washers at low temperatures, it was necessary to place thin sheets of neoprene in the insulating joints between the loading members. This absorbs the impact of the fracturing specimen, and prevents cracking of the plastic washers.

To change specimens during testing, only the parts between D and F (Fig. 3) must be removed from the testing set-up. When these parts are disassembled, they are heated to room temperature and dried before re-assembly. This prevents the formation of ice which might result in eccentric loading.

The eccentricity of loading of this complete assembly was determined by obtaining stress-strain curves in the elastic region on opposite sides of a test specimen by means of two Huggenberger lever-type strain gages. The technique for obtaining these curves and for calculating the eccentricity is described in the paper by Sachs, Lubahn and Ebert, previously mentioned. The maximum eccentricity was approximately 0.002 inch.

Cooling Method

Since this equipment was to be used to obtain point by point stress-strain curves at various low temperatures, a method for holding the specimen at one temperature for a considerable time was developed. An insulated flask was made to surround the specimen and the loading members adjacent to the specimen (Figs. 1 to 4). The coolant, usually isopentane, with which the flask was filled, was held at the desired temperature by passing liquid nitrogen at a definite rate through a copper coil on bottom of the flask.

The equipment used to control the isopentane temperature is shown in Figs. 1 and 4. Since the nitrogen in the container is constantly absorbing heat, it evaporates continuously, to build up a considerable pressure. This pressure controls the rate of flow of the liquid nitrogen. As shown in Fig. 4, two escapes were built into the nitrogen container, one for gas and one for liquid nitrogen. The escape channel for the gaseous nitrogen has a built-in stop-cock to control the rate of flow of escaping gas. Since pressure built up by the vaporizing nitrogen is not always large enough to develop the desired rate of nitrogen flow, a pressure bulb was added.

When the specimen was to be tested at the lowest temperature, the refrigerating coils were not used. Instead, the liquid nitrogen was forced directly into the cooling flask surrounding the specimen at a rate which kept a constant level of nitrogen in the container.

To change specimens, it was necessary to design the cooling chamber with a removable front. This presented a problem of finding suitable gasket materials. It was found that neoprene sheeting was satisfactory with isopentane, and a heavy grease was satisfactory with liquid nitrogen.

At temperatures between —80 C and room temperature, the refrigerating coil caused too large a temperature fluctuation during the test, so that equilibrium mixtures were used. A convenient mixture was dry ice in a pentane or gasoline for —78 C).

When liquid nitrogen was used as the refrigerant with isopentane, the temperature fluctuated about ±2 C; also, the temperature difference between the top and bottom of the specimen was generally found to be about 2 C. When equilibrium mixtures were used (liquid nitrogen, dry ice and pentane), these fluctuations were smaller than the sensitivity of the temperature measuring equipment.

Measuring Strain and Temperature

To obtain strain data, it was necessary to develop a remote reading strain gage because readings could not be made directly on the specimen. A mechanical lever-type gage, shown in Fig. 5, was developed. The knife edge of the gage, made of aluminum to prevent scratching the specimen, rested on the specimen. Any movement of these knife edges was transmitted through long vertical members by a hinged joint to the indicator.

Since it was anticipated that the

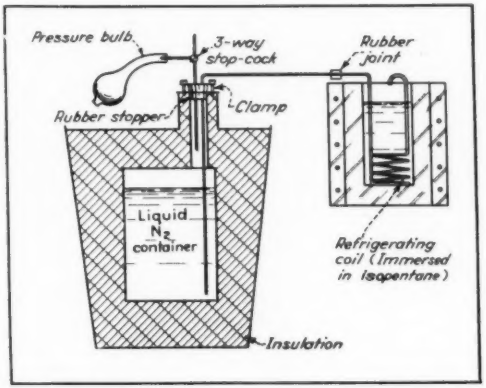


Fig. 4—Method of controlling temperature of coolant (isopentane) in flask. Liquid nitrogen passes through refrigerating coil.

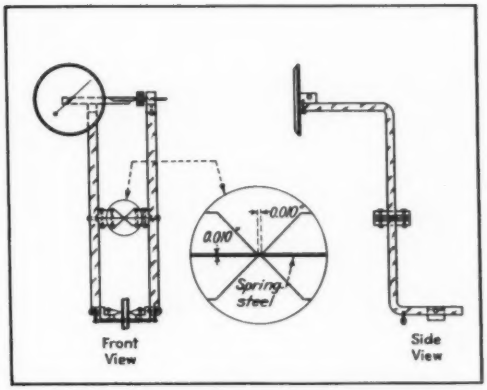


Fig. 5—Lever-type remote-reading strain gage has special hinge for low temperature operation. Knife edge is made of aluminum.

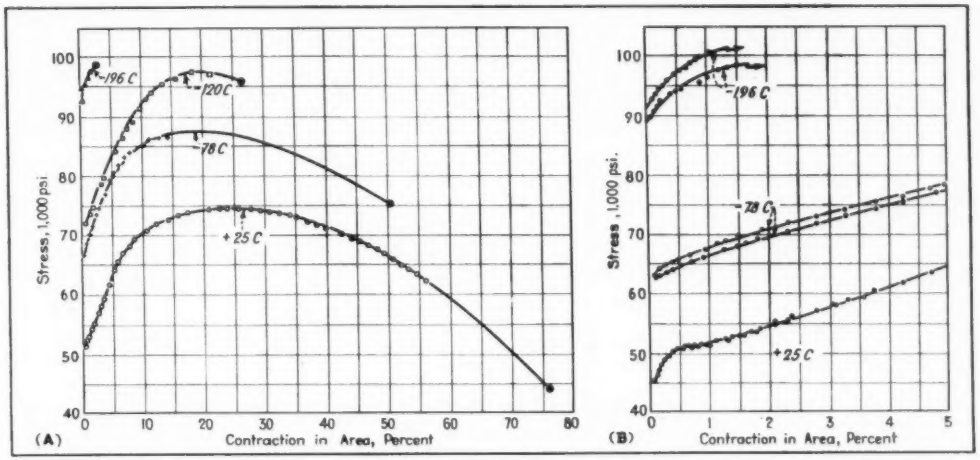


Fig. 6—(A) Stress strain curves on a 2.75 percent silicon steel at various temperatures. Uniform ductility change contrasts with sharp drop of mild carbon steels. (B) Enlarged curves show reduction of yield reversal as temperature is dropped.

formation of ice might hinder any sliding movement, the hinge (the only moving part) was not made in a conventional manner, but consisted of two steel clamps holding a piece of spring steel. Only about 0.010 in. of the steel was exposed between the clamps, and all bending took place in this short length.

Initial and final diameters of all specimens tested were measured on a microprojector. These values were used in calculating the strength and ductility properties of the material.

Temperatures were measured by placing the "hot" junction of two thermocouples in the two centering holes of the test specimens. These thermocouples, which represented temperatures at the top and bottom of the specimens were then run through a "cold" (O C, ice water) junction to a portable potentiometer.

Test Results

To demonstrate the kind of tests made with this equipment, stress-strain curves obtained with a 2¾ percent silicon steel are shown in Fig. 6. These curves were obtained on specimens which were slightly contoured (2 in. radius) to insure maximum strain and fracture at a predetermined position. It can be seen in Fig. 6 (*A*) that this steel does not behave like ordinary mild carbon structural steels as the temperature of straining is changed. Although the ductiliy (percent contraction in area) of most steels remains constant over wide temperature ranges and then changes abruptly over a narrow range, this steel showed a much more uniform decrease of ductility with decreasing temperature.

Fig. 6 (*B*) reveals that with decreasing temperature this steel "yields" increasingly more uniformly. The magnitude of the yield "jog" (reversal in the stress-strain curve) which appears at room temperature becomes smaller with decreasing temperature, and finally disappears.

EDITOR'S NOTE: This article is based on one of a series of reports in a research program conducted at the Metals Research Laboratory, Case Institute of Technology, Cleveland, Ohio, in cooperation with the Office of Naval Research, U. S. Navy.

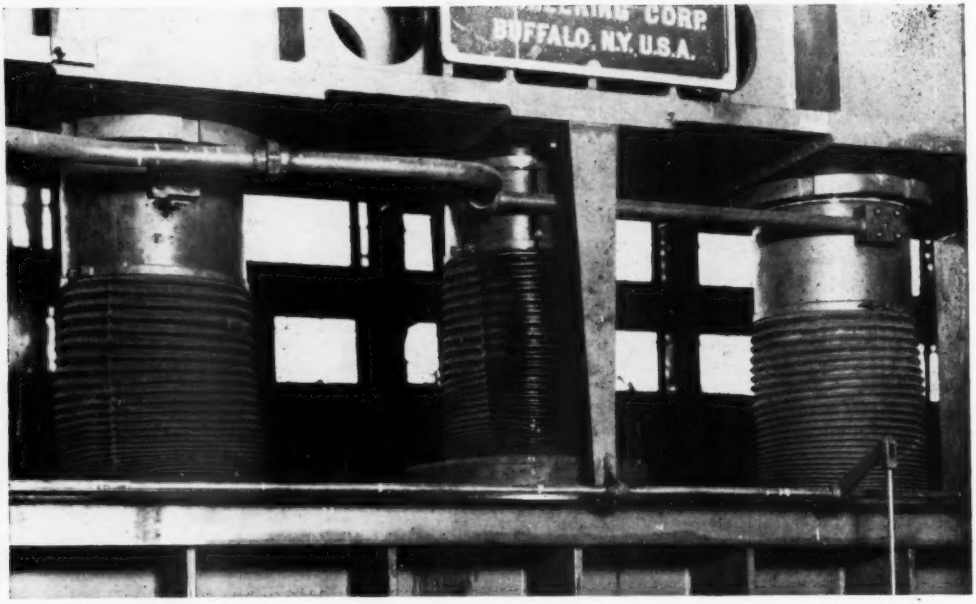


Fig. 1—Dust excluder boots made of cotton-reinforced synthetic rubber protect hydraulic press rams from mill scale and other abrasive particles during steel fabricating operations. The reinforced boots are strong, yet thin enough to take the required travel.

Protecting Machine Parts With Dust Excluder Boots

Limitations of conventional leather, fabric and molded rubber boots often impair operation of machines through admission of abrasive and other foreign particles. New reinforced synthetic rubber boots, available in a wide variety of styles, answer many design problems involving moving machine parts.

WATSON G. HARDING
United States Rubber Company

EXCLUSION OF DUST, abrasives and foreign particles from functioning parts of machines presents a special problem to the design engineer. Without adequate protection, abrasive particles damage smooth surfaces; bolts, nuts and other small objects can jam pistons, rams, worm gears and similar mechanisms. Packing subjected to abrasive wear requires frequent replacement.

Conventional dust excluder boots include those made of circular leather or coated fabric disks sewn together (Fig. 2); molded corrugated rubber; or merely a loosely fitting plain fabric sleeve that allows wrinkles to compensate for reciprocating motion of covered parts. Appearance of some of these conventional boots is rather sloppy; since the boot is usually exposed, it detracts from the sales appeal of the overall machine.

Limitations of conventional dust excluder boots are especially apparent in applications having exacting dimensional and operating requirements. An example of this was seen in protective boots for aircraft actuating devices. "Travel" requirements — allowable space with the boot in a closed position—were not met with conventionally molded rubber boots because of the thin walls of about 0.030 in., sometimes with fabric insertions.

In many applications, space restrictions limit allowable outside diameters of dust excluder boots. This prevents the use of many conventional types, especially sewn boots, which depend, for travel characteristics, on "high corrugations"—large outside diameters, relative to inside diameters.

To protect mechanisms with long travel distances from foreign particles, metal telescoping tubes have been used. These have even greater disadvantages than other conventional types: (1) Not even the smallest amount of misalignment can be compensated for; (2) they are quite expensive; (3) they are subject to corrosion; and (4) they wear from grit particles that are trapped between the sliding tubes.

To overcome these limitations of properties and dimensions, a process has been developed which produces circumferentially corrugated boots, with inside diameters from $\frac{1}{4}$ to 36 in., without the use of molds. Synthetic

Table I—Properties and Applications of Dust Excluder Boots

Material (corresponding to style no.)	Comparative Properties	Application Characteristics	Resistance to Oil and Solvents (see Table II)	Typical Uses
1	Most rugged; lowest travel	Resistant to tearing, rough service or handling; laced closure available	Good	Large hydraulic press rams; pistons subjected to sand, stone, cinders
2	Less rugged than 1; better travel	Fairly resistant to tearing, rough handling; laced closure available	Good	Small hydraulic press rams; for rugged service on machine tools
3	Less rugged than 1 or 2; better travel	Comparatively high travel with fair resistance to tearing; laced closure available	Good	On machine tools and actuators where more rugged boot than 5 is required
4	More rugged than 3; considerably more travel	Greater travel than 1, 2, or 3; tearing resistance about same as 3; cannot be furnished with laced closure	Good	On machine tools where more travel than obtainable from 3 is required
5	Least rugged; highest travel	Highest travel; for applications where space limitations are important cannot be furnished with laced closure	Good	On actuators, machine tools and fairly delicate mechanisms, where high travel is necessary

rubbers, or fabrics treated with synthetic rubber formulations, are used. A typical synthetic rubber boot of this type, having an inside diameter of 2½ in., outside diameter of 3¾ in., a wall thickness of 0.030 in. with about 65 corrugations, will extend from 4 in. in a closed position, to about 38 in. when fully opened.

Types Available

Boots made by the new process can achieve travel characteristics obtainable in conventional sewn boots only by high corrugations. With a large number of small corrugations, a smaller outside diameter is the result.

Dust excluder boots made by the new process are available in the following materials:

Style No. 1—wall 0.060 in. thick, 12 oz cotton duck processed with synthetic rubber.

Style No. 2—wall 0.050 in. thick, cotton sheeting processed with synthetic rubber.

Style No. 3—wall 0.030 in. thick, cotton stockinette processed with synthetic rubber.

Style No. 4—wall 0.050 in. thick, seamless cotton stockinette with inner liner of synthetic rubber.

Style No. 5—wall 0.030 in. thick, synthetic rubber.

These styles are representative of the most common standardized constructions only. When more ruggedness or resistance to outside abrasion is required, a heavier protective rubber coating can be used. Boots can be made of glass or asbestos fabrics when service temperatures are above 250 F, the limit for use of cotton fabrics.

Properties and Design Factors

Ruggedness—resistance to piercing or wear from tools, sharp objects and abrasive particles—is the most important property requirement of dust excluder boots. However, this is limited by travel requirements—the maximum distance that the boot will be stretched during normal operation of the mechanism. Travel obtainable in dust excluder boots depends on wall thickness, material, and inside diameter of the boot. Fig. 3 and Table I show travel characteristics of boots of different materials.

These boots, with the exception of style Nos. 4 and 5, are also available with laced closure, which allows them to be installed without dismantling the equipment, and allows inspection or replacement of the covered part. However, travel obtainable is reduced from 10 to 20 percent. Fig. 8 shows a split and laced boot which protects pistons and cylinders of an aircraft landing gear from abrasive particles, and is easy to remove and replace.

Fabric reinforced types are more rugged than those made of plain rubber, and hence are used more commonly. One of the chief disadvantages of an all-rubber boot is the danger of being pierced by a screwdriver or other tool. However, both plain and reinforced boots made by the new process occupy less space (smaller OD) than

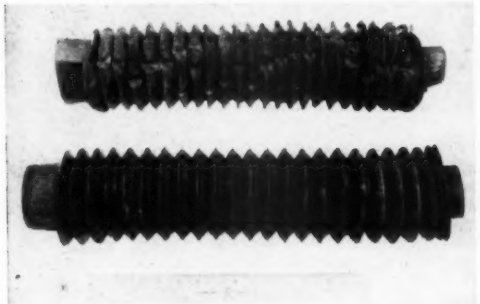


Fig. 2—Boot to protect shock strut on tail wheel of aircraft from sand blast created by propeller. Above, old style boot, made of 48 canvas pieces sewn together. Below, vulcanized synthetic rubber boot has only one seam that cannot open.

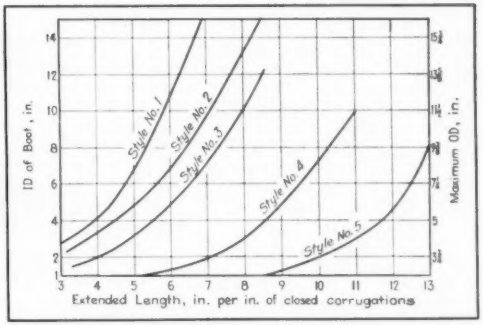


Fig. 3—Maximum travel obtainable vs. ID of dust excluder boots. Figures on right-hand scale do not increase in equal increments, since the relationship between ID and maximum OD is not linear. However, ID is the important limiting factor.

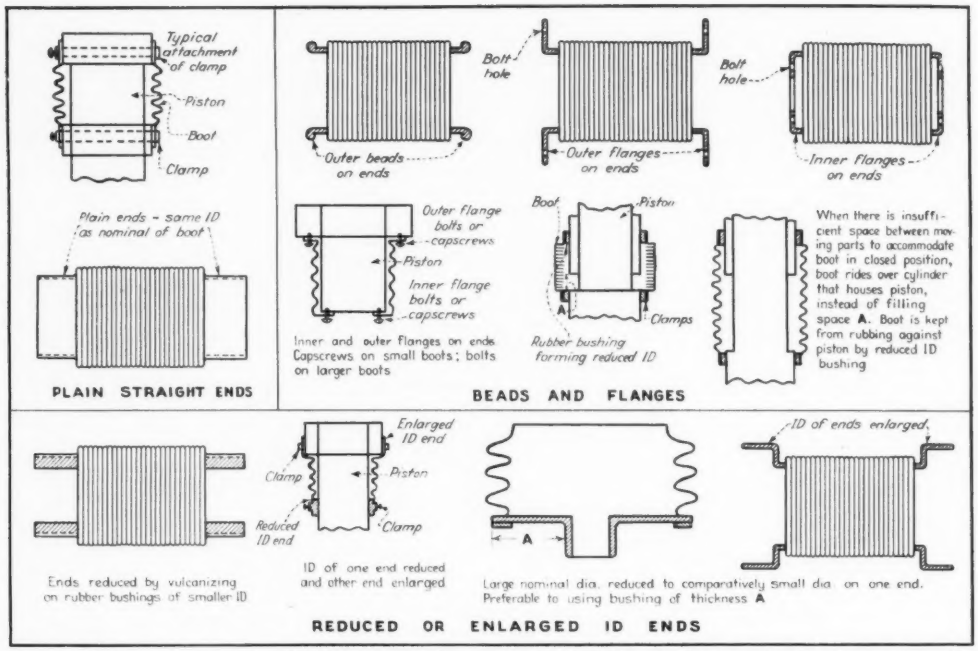

Typical attachment of clamp
Piston
Boot
Clamp
Plain ends - same ID as nominal of boot
PLAIN STRAIGHT ENDS
Bolt hole
Outer beads on ends
Outer flanges on ends
Bolt hole
Inner flanges on ends
Outer flange bolts or capscrews
Piston
Inner flange bolts or capscrews
Inner and outer flanges on ends. Capscrews on small boots; bolts on larger boots
Boot
Piston
A
Clamps
Rubber bushing forming reduced ID
When there is insufficient space between moving parts to accommodate boot in closed position, boot rides over cylinder that houses piston, instead of filling space A. Boot is kept from rubbing against piston by reduced ID bushing
BEADS AND FLANGES
Enlarged ID end
Clamp
Piston
Reduced ID end
Clamp
Ends reduced by vulcanizing on rubber bushings of smaller ID
ID of one end reduced and other end enlarged
A
ID of ends enlarged
Large nominal dia. reduced to comparatively small dia. on one end. Preferable to using bushing of thickness A
REDUCED OR ENLARGED ID ENDS

Fig. 4—Ends for attachment are furnished in a variety of shapes and styles. Methods vary with the application and type of material.

conventional types. Thus resistance to impact or abrasion can be achieved without making major design changes. Table I indicates factors that determine choice of material and style.

For most applications, in which there is reciprocating motion up to 30 cycles per minute, these boots have satisfactory fatigue characteristics. Above 30 cpm, shorter service life can be expected. Since reciprocating motion is involved, shape of dust excluder boots is usually circular. However, for special applications, these boots can be made in oval, square or irregular cross-section.

Resistance of these boots to water, oils, grease, coolants and high temperatures is excellent. This can be attributed chiefly to the use of synthetic rubber, the properties of which, shown in Table II, are superior to natural rubber. For high temperatures—up to 350 F—these boots can be made of glass or asbestos fabrics.

Methods of Attachment

Methods of attachment are shown in Fig. 4. Ends for attachment can be furnished as plain straight; with inside diameter reduced or enlarged relative to the nominal inside diameter of the boot; with outer beads, or outer or inner flanges. Plain ends, which have the same ID as the nominal ID of the boot, are sometimes attached merely by designing for a tight friction fit. In most applications, however, a wire clamp is used on the smaller diameters —up to about 6 in.—and a band clamp on larger diameters. Boots with enlarged or reduced ends are usually attached in the same way as boots with plain ends.

Boots with outer or inner flanges on the ends are provided with screw or bolt holes. Small boots are usually attached with cap screws and larger boots with bolts. In some applications these flanges are backed up with split metal flanges.

Dimensions can be varied almost indefinitely, since molds are not required to produce these boots. For this reason, also, experimental samples can be produced comparatively inexpensively. However, height of corrugations for a given ID and material cannot be varied. Extremely long and flexible boots, operating horizontally, can sag, with the possibility of corrugations being caught in the moving machine parts. The usual remedy for this condition is to allow the boot to ride in a trough, or to suspend the boot by another method.

When calculating length, enough slack should be allowed to prevent the boot from being overcompressed or overextended when the machine is in minimum or maximum travel position.

Some method of venting corrugated dust excluder boots is usually necessary. However, it has been found that some venting is achieved through ends, since an airtight attachment is not usually made. Laced closure boots do not usually require vents.

As shown in Fig. 5, for small size boots—$\frac{1}{2}$ to 10 in. ID—one or more small holes, 1/32 to $\frac{1}{8}$ in. are required for venting. Large diameter boots—

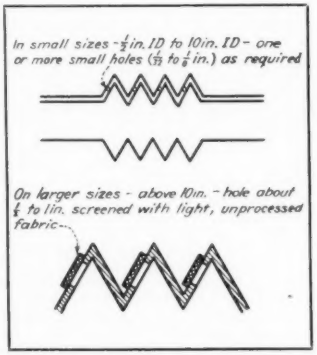

In small sizes - ½ in. ID to 10 in. ID - one or more small holes (1/32 to ⅛ in.) as required
On larger sizes - above 10 in. - hole about ¼ to 1 in. screened with light, unprocessed fabric

Fig. 5—Venting of dust excluder boots is often necessary, although laced boots, and boots with loosely-attached ends, do not require special provision for venting.

above 10 in.—are vented with ½ to 1 in. holes, which are screened with light, unprocessed cotton fabric.

Applications

First application of these boots were in aircraft, principally on actuating devices and landing gear struts. However, widest use is now in the industrial field. Typical uses of these boots are on:

Rams of hydraulic presses used in making grinding wheels or any other products where abrasive materials are formed.

Pistons on railroad cars, located underneath the cars and subjected to cinders and other injurious materials.

Pistons on tractors, dump trucks and earth moving machinery.

Adjusting screws on grinders and various machine tools.

Guide rods of large mechanical stamping presses, to protect them from loose scale from the metal parts being formed.

Worm gears of grinding machines.

Where pistons and worm gears are on machines used in cement, tile, porcelain, pottery, brick, and coal mining industries, dust excluder boots are particularly applicable.

To design dust excluder boots successfully, the following requirements must be known:

1. Nominal inside diameter or cross section of boot, allowing clearance for the part to be protected.
2. Maximum allowable space for corrugations when compressed.
3. Maximum travel of part.
4. Maximum allowable OD.
5. Type of ends required for attachment and their dimensions.
6. Oils, greases, abrasives, or other materials to which the boot will be subjected, inside and outside.
7. Miscellaneous abuses, such as tools and falling objects to which boot might be subjected.
8. Maximum and minimum service temperatures.
9. Rate of operation.
10. Whether maintenance of protected parts is a special problem.

To illustrate how these design data are used, the following case histories of actual applications are presented:

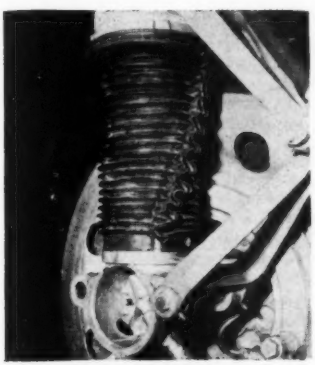


Fig. 6—To protect aircraft landing gear from abrasive substances, boot is split lengthwise and laced to permit quick removal for inspection. Wire clamp attachments are at top and bottom of boot.

Landing Gear Struts

THE PROBLEM: To protect pistons of aircraft landing gear struts from sand that is blasted on them by the propeller.

THE SOLUTION: Boots for these applications were made of thin rubberized fabric, style no. 2, to take the required travel. As shown in Fig. 6, the upper end was enlarged to attach to the cylinder in which the piston travels. When necessary to apply the boot without dismantling the strut, a laced boot is used.

Aircraft Actuators

THE PROBLEM: to design a boot to protect a screw jack assembly in aircraft actuators. Since this nut and screw assembly is comparable to a ball bearing, the exclusion of grit is imperative for proper operation. The actuators are used in many different sizes and in many applications—to operate nose and main landing gears, wheel doors, wing flaps, trim flaps, tail skids and dive flaps. They are also used to operate folding wings and locks on carrier based aircraft.

The nature of the application limited allowable closed length and outside diameter. The ratio of travel to closed dimension was high. Ends for attachment had to be inner or outer flanges, because of space limitations. The material had to be oil resistant, not over 0.030 in. thick, and operate without stiffness at —65 F. No conventional boots would meet all these requirements.

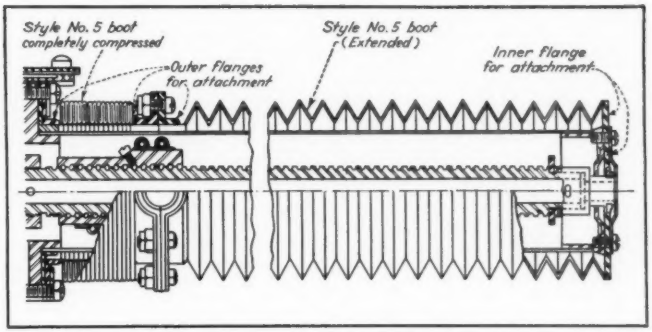

Style No. 5 boot completely compressed
Outer flanges for attachment
Style No. 5 boot (Extended)
Inner flange for attachment

Fig. 7—Aircraft actuator limits allowable closed length and outside diameter of dust excluder boot. Since ratio of travel to closed dimension is high, and oil and low temperatures affect efficiency of operation, unreinforced synthetic rubber boot is used.

Table II—Oil and Chemical Resistance of a Typical Synthetic Rubber Compound Used in Boots

(Before and after immersion or air heating)

	Before	After 120 hr in hydraulic oil @ 158 F	After 70 hr @ 212 F in Petroleum Base # 3 Oil	After 70 hr in hot air @ 212 F	After 70 hr in boiling coolant solution (1/3 Prestone 1/3 alcohol, 1/3 water)
"A" Durometer	55	48	60	67	67
Elongation, %	367	——	246	176	250
Tensile strength, psi	2020	——	2070	1760	2250
Volume change, %	——	+13.4	+1.6	——	——
Brittle Point, F	—65	——	——	——	——

The material chosen was style no. 5, unreinforced synthetic rubber.

THE SOLUTION: Boots designed as shown in Fig. 7.

Hydraulic Press Rams

THE PROBLEM: To design dust excluder boots for rams of hydraulic presses used for making products composed of abrasive materials such as

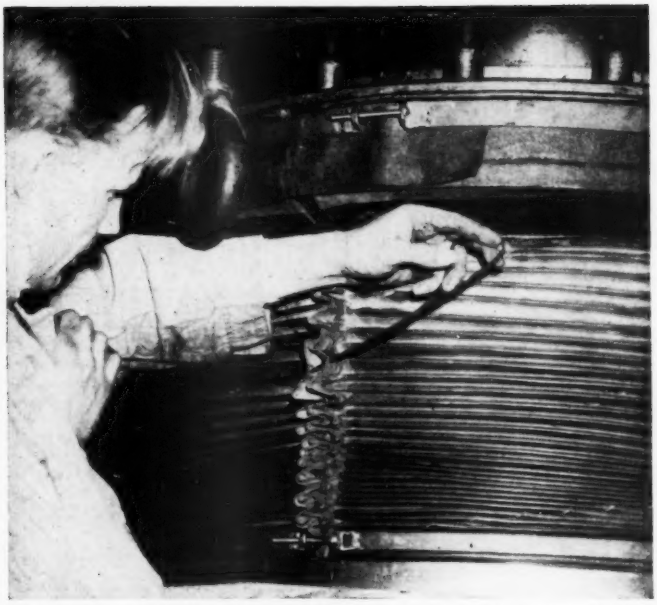


Fig. 8—Ram of hydraulic press used in making grinding wheels is protected from abrasive dust with 33 in. ID laced fabric-reinforced synthetic rubber boot.

synthetic resin bonded grinding wheels. These abrasives score the ram, making removal and refinishing necessary. They also cause excessive wear on the ram packing.

This particular problem involved covering a ram 32 in. in diameter, requiring a 33 in. ID boot. The corrugated section had to extend from a length of 6 in. closed, to 22 in., open. It was desirable that the boot be strong, yet thin enough to take the required travel. An all-rubber boot was not suitable because of insufficient strength, and difficulty of molding and handling expense.

THE SOLUTION: A fabric-reinforced boot, style no. 2, was designed, with proper dimensions, resistance to oil, and short plain ends for attachment. When the press must be dismantled to apply a boot, a slit boot with a laced closure should be used. This closure is formed at the same time as the boot and does not restrict the movement of the boot. Shown in Fig. 8 is a laced boot, 33 in. ID, on a press making grinding wheels.

Railway Car Brakes

THE PROBLEM: To protect air pistons that actuate the brakes on some stainless steel railway cars from cinders, gravel, dirt and water which are thrown up from the roadbed. Each truck has four pistons, and each car has two trucks. Conventional sewn leather boots have been used.

THE SOLUTION: Rubber-fabric boots, style no. 1, were preferred because of better appearance, elimination of sewn seams, and because they would not absorb water and freeze in the winter. The boots had to be made of a compound to resist outside abrasion, temperatures down to —40 F, and oil and grease. One end of these boots was reduced in diameter.

Contour Grinding Machine Parts

THE PROBLEM: To maintain precision by keeping abrasive dust out of three of the reciprocating parts, preventing wear. It is claimed that this machine will dress any complex contour on an abrasive wheel to 0.0002 in. The long travel, thin wall and limited outside diameters made conventional boots of rubber, leather or canvas unsuitable.

THE SOLUTION: Boots, as shown in Fig. 9, made of style no. 5 material, which keep out the abrasive dust and maintain the precision of the machine.

Fig. 9—Three unreinforced synthetic rubber parts protect precision parts from abrasive dust on the Hoglund contour wheel dresser. Two of the flexible corrugated boots slip over the template slide and piston rod mechanism. The third part is a flexible neoprene hood that shields the bearings directly under the grinding wheel.

Dust excluder boots made by the new process are not offered as a universal solution to all dust exclusion problems. Certain types of heavy walled, short travel rubber boots, with inner beads or grooves on the ends, can be most economically produced by conventional molding methods.

However, a wider use of dust excluder boots seems worth exploring. The benefits derived include assurance of dependable functioning by protection of equipment from being jammed by loose objects, and savings in maintenance and lost production caused by scored pistons or rams, or packings made ineffective by abrasive materials.

Laminated Plastic Bearings for Heavy Duty and Severe Service

Laminated plastic bearing materials have proven themselves in a wide range of heavy duty and severe service applications. Advantages and limitations of these materials in bearing design are presented in the light of this experience. Properties and several of the more important applications are described in detail.

E. P. LITTLEFIELD
Engineer, Chemical Department,
General Electric Company

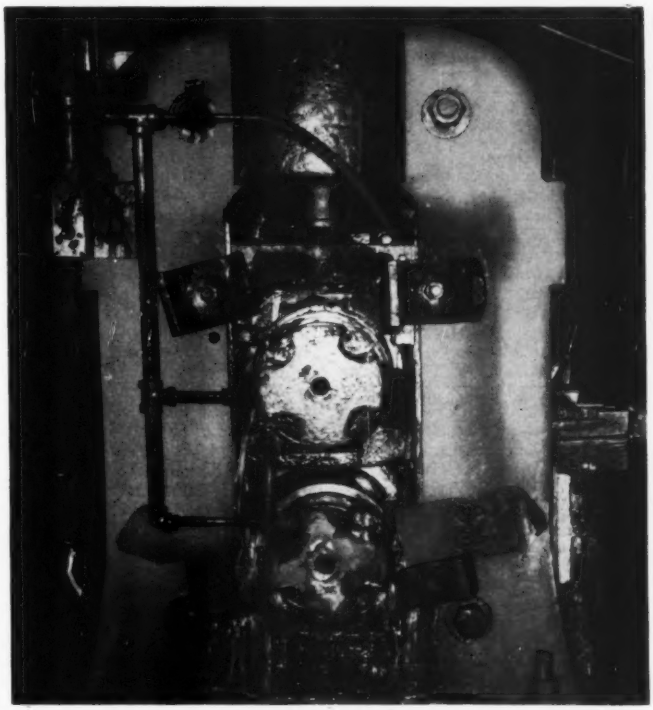


Fig. 1—Laminated plastic roll-neck bearings withstand high bearing pressures and temperatures in steel mills, materially lengthening time between replacement shutdowns.

LAMINATED MATERIALS, molded under high pressure of a woven fabric base bonded with thermosetting resins, are used extensively for bearings. In applications where shock caused by variable loading must be absorbed, as in steel mills (Fig. 1), these materials have replaced babbitt, bronze and lignum vitae. They give greater bearing life and reduced friction loads; power savings from 25 to 60 percent have been reported.

Of the numerous fabrics available, two are now in general use: A relatively fine weave cotton duck weighing about 10 to 15 oz per sq yd and a single-ply woven cotton cord duck, weighing from 20 to 30 oz per sq yd. These fabrics are impregnated with phenol-type synthetic resins until they contain about half their weight of solid resin. This impregnated material is laminated to the required thickness and then molded under one to two tons per sq in. pressure, at temperatures up to 350 F.

Properties

Principal properties of these materials, to be considered in bearing design, are impact strength, compressive strength, absorption and expansion when in contact with fluid lubricants, thermal expansion, thermal conductivity, resistance to corrosion, coefficient of friction, rate of wear, and resilience under bearing pressure. These properties will be considered for the commonly used types of laminated bearing material.

BEARING STRENGTH. Impact strength is measured perpendicular to the laminations, for consideration in bearing design. These values vary from 5 to 8 ft-lb per sq in., fine weave duck, to 14 ft-lb per sq in. for the heavy cord duck. This property is to some extent a measure of the laminate's ability to resist cracking from the direct effects of impact from the journal. According to ASTM test methods, compressive strength of these materials averages about 40,000 psi in the direction perpendicular to the laminations.

In bearing design, the important strength factor to be considered is a combination of static and dynamic loading—compressive and impact strengths. The maximum total bearing pressure that these laminates can withstand—the combination of static and dynamic pressures—is 40,000 psi. However, this is a theoretical value, and is greatly reduced by practical considerations such as rubbing speed, amount and type of lubrication, clearances and type of loading. In practice, it has been found that plastic laminates are successful bearing materials for loads up to 6,000 psi. Above that value, high friction losses and cold flow of the laminate limit the efficiency of the bearing.

RESILIENCY. The dynamic or impact component of the bearing load, which often represents high instantaneous pressures, is sometimes overlooked by designers. This portion of the load is

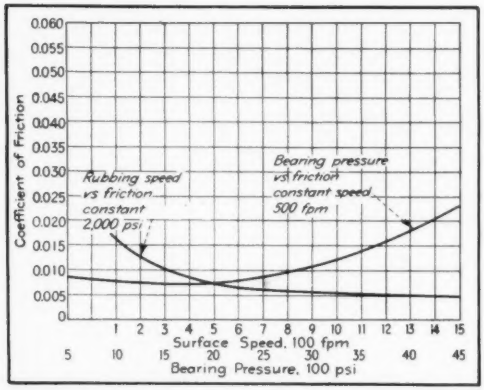


Fig. 2—Loss of efficiency in a water lubricated laminated plastic bearing depends on relationship between rubbing speed and bearing pressure, and coefficient of friction.

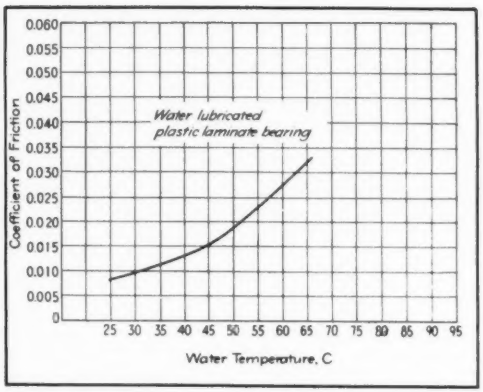
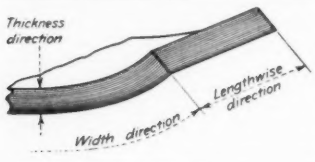


Fig. 3—A composite of many different tests, this curve is applicable to water lubricated bearings run at a surface speed above 1,000 fpm, and approximately 2,000 psi bearing pressure.

partially absorbed by the natural resiliency of the material. In bearing laminates the resiliency is much greater than in many metallic materials. For plastic laminates this "spring" value is in the order of 0.002 in./1,000 psi/in. thick. This means that the laminate should not be more than $\frac{1}{2}$ in. thick for every 1,000 psi per 0.001 in. allowable "spring". Naturally, expected deflection in the bearing blocks and the machine frame should be added in determining total "spring". For this reason, laminate bearings cushion shock transmission between machine components, and can be designed for much higher intermittent loading than metallic bearings.

Table I—Free Absorption Expansion of Bearing Segments



Fluid	Expansion, in. /in. at Saturation Thickness	Width*	Length
27 oz Cotton Duck Base			
Fresh Water	0.025	0.005	0.010
Salt Water	0.025	0.005	0.012
Machine Oil	0.005	0.003	0.003
Gasoline	0.006	0.002	0.002
15 oz Cotton Duck Base			
Fresh Water	0.025	0.005	0.006
Salt Water	0.025	0.005	0.007
Machine Oil	0.005	0.002	0.003
Gasoline	0.004	0.001	0.002
8 oz Cotton Duck Base, With Graphite			
Fresh Water	0.016	0.006	0.008
Salt Water	0.016	0.005	0.008
Machine Oil	0.003	0.002	0.004
Gasoline	0.002	0.002	0.003

*Values in width direction are per inch of arc length.

Dimensional Stability. Laminated bearings always expand to some extent when in contact with a fluid lubricant or atmospheric moisture, because of absorption, causing high spots which wear most rapidly. This must be compensated in design, to avoid bulging of the bearing surface. Tables I and II demonstrate this property for various laminate materials and fluids. The data given for gasoline absorption is of interest when designing blades and bushings in gasoline pumps; however, gasoline is not recommended as a lubricant in other types of bearings.

Some of the absorption expansion at the bearing surface will be compensated by wear. However, in good design this should not be considered, since the expansion pressures are quite high and result in overloading, with attendant heating and rapid wear. Space for this expansion must be allowed in every direction except in the backing surfaces of the bearing, which should be of solid construction and retain original dimensions.

Running clearances for laminated bearings are generally of the same order as those used for metallic bearings with similar lubricants. Exact figures are not given inasmuch as the running clearance allowances are well established, based on work conditions such as pressure, speed and lubricant. It should be noted, however, that expansion allowances as given in the table of absorption expansion must be added to the running clearances to obtain a satisfactory design.

Table II—Free Absorption Expansion of Laminated Tube Bearing

Fluid	Expansion, in./in. at Saturation Thickness	ID	Length
8 oz Cotton Duck Base, With Graphite			
Fresh Water	0.028	0.005	0.003
Salt Water	0.024	0.005	0.005
Machine Oil	0.002	0.002	0.0007
Gasoline	0.004	0.001	0.0007

Thermal expansion of laminated plastics are of small magnitude compared with absorption expansion. Thus, the allowance for absorption is usually sufficient to include the thermal expansion. However, this property is an important consideration, since the different rates of expansion of the laminate and the metallic parts of a bearing which are in close affinity, can cause distortion when the parts are at an appreciably different temperature. Both of the previously mentioned laminates have a 0.00003 in./in./C coefficient of thermal expansion.

Conductivity. Plastic laminates are poor heat conductors. At usual machine temperatures, the conductivity value is about 2.5 Btu/sqft/F/in. Thus, heat generated or transmitted to the journal must be carried away through the lubricant to prevent a dangerous temperature rise.

Circulating oil systems, or water lubricating and cooling systems usually accomplish this result by conducting the heat into the frame of the machine or by secondary exchange into the lubricant reservoir. Careful con-

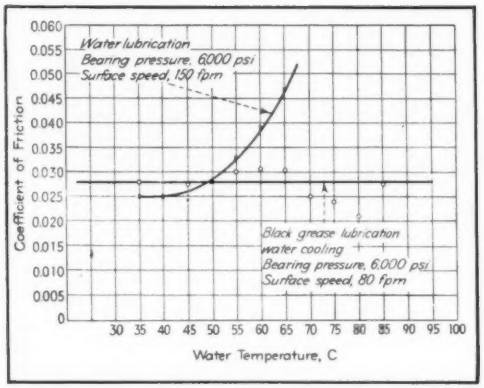


Fig. 4—Comparison of water and grease lubrication for laminated plastic bearings at low surface speeds and heavy pressures. At these low surface speeds, grease lubrication should be used.

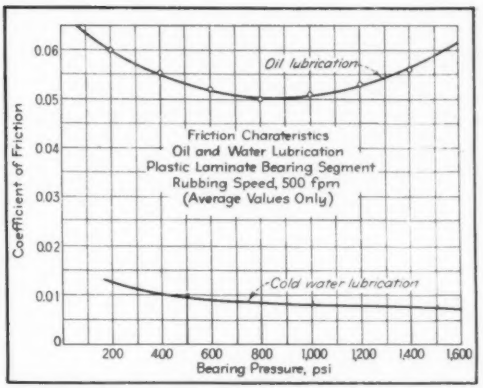


Fig. 5—Bearing pressure vs coefficient of friction for water and oil lubricated laminated plastic bearing segment. The rubbing speed was held constant at 500 ft per minute.

sideration of conductivity is one of the most important factors in plastic bearing design, since the accumulation of heat in the journal is rapid and can quickly reach the charring temperature of the laminate.

CHEMICAL RESISTANCE. Resistance of plastic laminates to deterioration from various agents varies somewhat for the different grades. However, chemical properties of the most common bearing laminates are fairly similar. Plastic laminate bearings are destroyed by hot strong alkaline solutions. Mild acids have only a moderate effect and hydrocarbon solvents do not attack them to any appreciable extent. Lubricants should be checked for any corrosive agents that might be present; however, such contamination is usually more harmful to a metallic journal than to a plastic laminate.

FRICTION LOSS. Loss of efficiency of laminated bearings caused by friction phenomena is described in Fig. 2. Effect of lubricants on coefficient of friction under various conditions are shown in Figs. 3, 4 and 5. These values are a reliable index of actual operating conditions. At low speeds and heavy loads a grease lubricant is required; water serves as a coolant. Such friction values are used in machine design to determine power loss, temperature rise, and lubrication and cooling requirements.

Water is the most widely used lubricant for laminated bearings because it offers the lowest friction losses and because of its general availability. Steel mills and marine applications are two uses where water is a natural lubricant.

The material of which the journal is made and its finish has just as much an effect on friction loss of laminate bearings, as on that of any other type of bearing. It has been found that when a fine grained nickel-iron alloy, ground and highly polished, is used, friction losses are as much as 50 percent less than losses incurred when a soft steel journal is used—this result was achieved when laminate bearings and cold water lubrication were used. This fact can be used advantageously by simply placing sleeves of this nickel-iron alloy over the regular steel journal body.

The ratio of journal to laminate wear is indicated in Fig. 6, for an iron journal with water lubrication at constant load and rubbing speed. These values should be used only as a general reference, since they were obtained in tests and not under actual operating conditions.

Design Problems

Most common applications for plastic laminated bearings are in rolling mills and marine service. In rolling mills, water lubrication is generally used. The bearing component is generally a molded laminated segment, proportioned to suit the journal and bearing housing. In marine bearings, the material is usually in the form of strips or staves inserted into a metallic shell with allowances for absorption expansion and easy replacement.

When babbitt or bronze lined bearing housings or blocks are on hand, they are easily remachined to hold laminate bearing segments (Fig. 7).

The methods of securing laminate

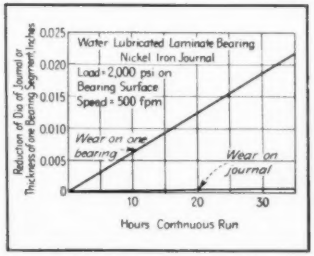

Water Lubricated Laminate Bearing
Nickel Iron Journal
Load = 2,000 psi on
Bearing Surface
Speed = 500 fpm
Wear on one bearing
Wear on journal
Reduction of Dia. of Journal or Thickness of one Bearing Segment Inches
Hours Continuous Run

Fig. 6—Journal and laminate bearing wear at constant speed and constant load.

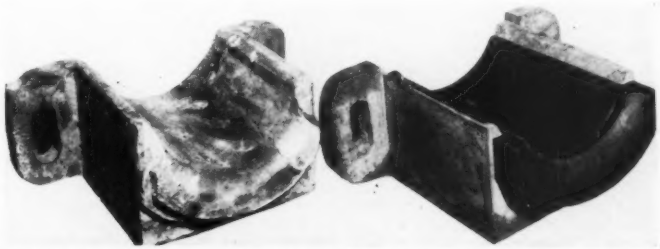


Fig. 7—Steel mill bronze bearing lining (left) can be remachined and replaced with plastic laminate components, as shown installed in bearing chuck at right.

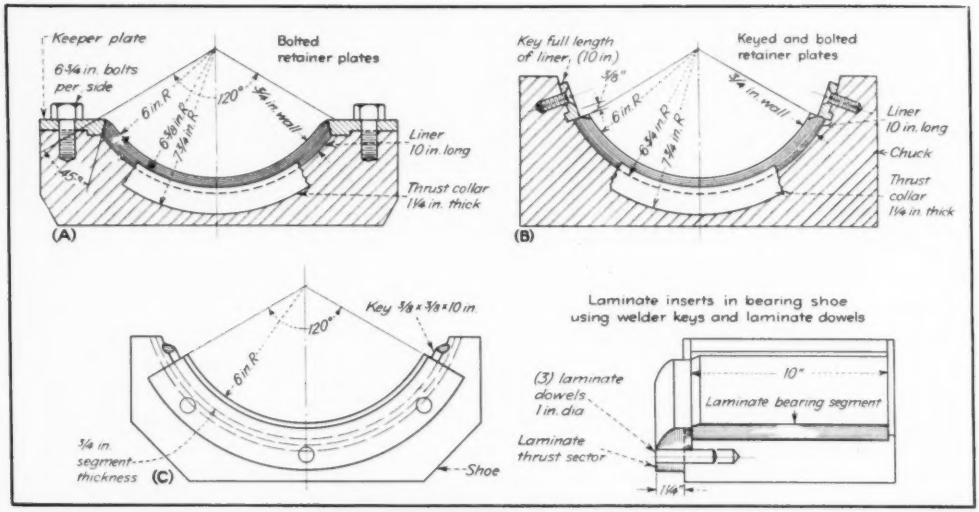


Fig. 8—Choice of method of securing laminate components to bearing blocks depends on safe radial force and tangential friction force. The relative strength of these arrangements to resist stripping is of interest to the designer. Three methods are commonly used: A, bolted retainer plates; B, keyed and bolted retainer plates; C, laminate dowels.

components to bearing blocks are shown in Fig. 8. Relative strength of these arrangements to resist stripping is important in design. Assuming a bearing component as in Fig. 8(A), the friction force acting tangent to the radius is exerted on a clamping plate by the angular surface at the edge of the plastic segment. This distributes the force approximately half as tension on the bolts, and half as thrust on the step of the clamping plate. Since the safe working stress of a ¾ in. steel bolt is about 1130 lb, the tension component of the radial force can be 13,560 lb without stripping from the block. With a dry coefficient of friction of 15 percent, as in a lubrication failure, this would require about 8,600 horsepower at 1,000 rpm. This indicates that bearing seizure would have to be sudden and complete to strip out the bearing liner.

Fig. 8(B) shows a bolted key plate, of the type used in actual practice. Assuming that the safe shear stress on the steel key is 12,000 psi, the tangential force on the plastic could be 45,000 lb. Fig. 8(C) shows two other common methods for holding laminate segments in bearing blocks. Their relative resistance to stripping is about 22,500 and 6,800 lb respectively.

For the thrust component of this open type bearing, Fig. 8(C) shows the thrust collar machined from a flat sheet of laminate fitted with a dovetail rabbet in the block and held in place by three laminated plastic dowels. For comparison purposes, consider the dowels one inch in diameter and having a safe working stress of 5,000 psi in shear. The apparent safe tangential load is then 11,775 lb.

Laminated dowels are often used for holding radial bearing segments in the block when there is no space to apply bolted or welded steel keys. They have the disadvantage of necessitating dismantling of the whole bearing block from the machine to replace the segment.

When loads on the radial and thrust bearing surfaces are appreciably different, causing more rapid wear on one surface, separate bearing surfaces should be designed, so that the worn component can be replaced without sacrificing the remaining life of the other one. If there is equal pressure on both surfaces, however, a unit having both surfaces molded in offers simplest replacement when worn out. Such a unit is sometimes made necessary by the shape and amount of space available.

Large machine parts, such as rolling or crushing mill rollers, have bearings with molded segments of about 120 deg arc on those portions of the journal were maximum forces are exerted. With proper thrust sectors attached to the bearing blocks, relatively narrow strips (30 deg arc or less) of plain flat laminate, Fig. 9, are located to provide stabilizing side bearings.

The arc of contact with the journal should be made less for plastic laminates than for metallic bearing surfaces, because more of the journal surface should be exposed to the cooling action of the lubricant. It also avoids the use of an expensive material on the side of the journal where bearing pressures are comparatively light.

With water lubrication, friction losses for plastics laminates become greater with increasing unit pressures, making the lubrication problem more serious. It is desirable to have as large a bearing area as possible while satisfying the short arc requirements. For this reason, laminate bearings are usually made as long as practicable along the axis of the journal. When converting to laminate bearings, this length is generally the full available length, and for new applications, the bearing design should be proportioned in accordance with these principles. In water lubricated bearings, there should be not over 3,000 psi pressure on the projected bearing surface.

For oil lubrication, the pressure-friction work to be dissipated as heat must be transferred from the journal by the oil stream. Thus, bearing areas should be designed large enough to keep unit pressures low. The rate of heat generation can be approximated as

$$\frac{F \times P \times S}{778} = \text{Btu/sq in. of bearing surface}$$

where

F = coefficient of friction
P = journal pressure on bearing surface in psi
S = rubbing speed of the journal in ft/min

When it is necessary to design laminate bearings to carry bearing pressures that will generate heat faster than

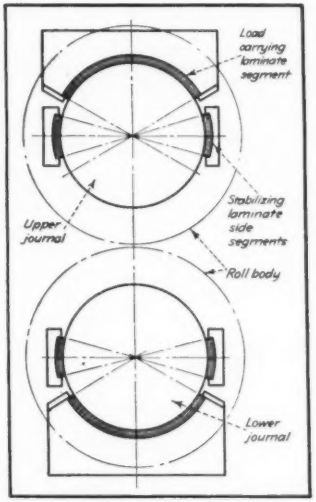


Fig. 9—Narrow arc side segments are used to stabilize and hold side load components in large machine parts.

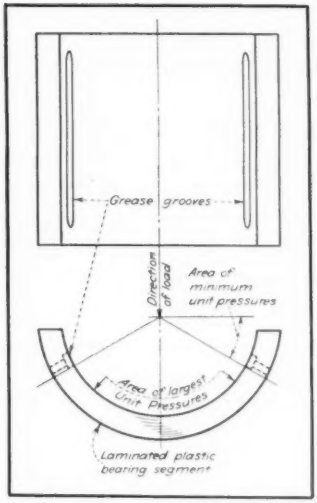


Fig. 10—Grooves or channels for feeding oil or grease to the bearing should be located on sides of radial segments.

the lubricant can carry it away, water is used for cooling, with grease or oil as the lubricant. This can take the form of a water-oil emulsion that is recirculated, or as grease applied to the bearing through channels in the laminate, or as blocks of grease applied directly to the journal with light pressure. In this type of application, water is sprayed on the exposed portions of the journal, just as when water alone is the lubricant. (Fig. 4 indicates friction losses in a test bearing with water cooling and grease lubrication). As shown in Fig. 10, grooves or channels for feeding oil or grease to the bearing should be located on the sides of the radial segments to avoid disruption of the bearing surface in the area of highest pressures.

Water-lubricated laminate bearings are used in cane and beet crushing mill rolls, where grease lubrication on metallic bearings often cause contamination of the product. When properly designed, a laminate water-lubricated bearing will provide lower operating cost through power and wear savings, and will not cause harmful effects if a little water reaches the product. In some steel sheet and strip mills, oil or grease leaking from the bearings causes staining of the product, which proves costly to remove for subsequent plating or finishing operations.

In another important application of plastic laminated bearings—underwater bearings for boats and hydraulic turbines—the surrounding medium offers the best lubricant and coolant.

Fig. 11 shows a propeller shaft bearing having relatively narrow laminate segments inserted in a bronze housing, with anchor keys and wedge split segments for tightly locking the assembly. In this type of assembly it is usually possible to change worn laminate components without disturbing the propeller shaft or the housing sleeve.

Where oscillating and intermittently loaded journals are needed, laminate bearings are useful because of their property of resilience, which serves to absorb shocks to other machine parts and deaden resultant noise. Such bearings only require a lubricant of sufficient viscosity to maintain the film. Since velocities are generally low in this type of bearing, the heat generated by friction is dissipated by conduction and radiation from the journal. Fig. 12 shows a one piece sleeve-type laminate bearing for use with oil ring lubrication on run-out table rolls in a brass rolling mill. Operation is intermittent, unit loads are moderate and the heat generated in the journal is easily transmitted to the machine frame by the oil.

Laminated plastics bearing elements also provide electrical or thermal insulation between a spindle and other machine parts, in addition to carrying considerable pressure and absorbing shock. The average low frequency dielectric strength safe working load is about 30 volts per mil for bearing laminates. Thus, an economically small bushing can be used to insulate against usual shop voltages. Bearing laminates are not suitable for high (radio) frequency insulation since the dielectric losses are high. Some common applications are rotating and oscillating journals in switch gears and coin operated devices.

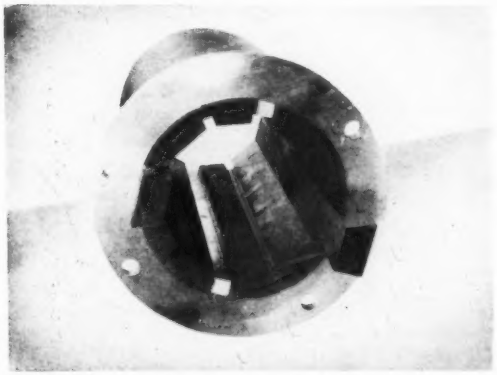


Fig. 11—Propeller shaft bearing with anchor keys and wedge split segments for tightly locking the assembly.

Fig. 12—One piece sleeve-type laminate bearing, oil ring lubricated, used on runout table rolls in a brass rolling mill.

Bonded Resistance Wire Gages

FOUR FACTORS must be considered when choosing the proper gage for a specific stress analysis. Gages of this type give an average reading for the overall gage length.

NATURE OF STRESS CONDITION. Stresses to be measured may be uniaxial or biaxial. Single element gages, shown in Figs. 1 to 6, will do the job when a strain measurement in one direction will give sufficient data. The directions of axes for biaxial stresses existing in airframes and complicated castings, for example, are usually unknown. Rosette gages (Figs. 7 and 8) are suitable under these conditions. Biaxial stress directions are sometimes known from considerations of symmetry or Stress-Coat analysis. A gage having two elements, as in Fig. 9, will fill this requirement. Certain stress conditions, though biaxial in nature, necessitate measurement of the principle stress only, the transverse stress remaining unmeasured. The "stress" gage (Fig. 10) is especially adaptable for this condition that is typical in propeller vibration tests where circuit components such as slip rings must be extremely simplified.

(A) UNIAXIAL STRESSES—simple tension or compression

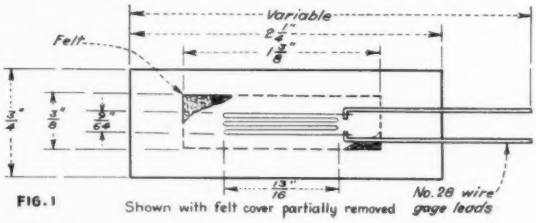


Fig. 1—Typical General-Purpose Gage. Used where space is not limited as on flat plates. Made in various sizes with grid lengths from $\frac{3}{8}$ to 1 inch.

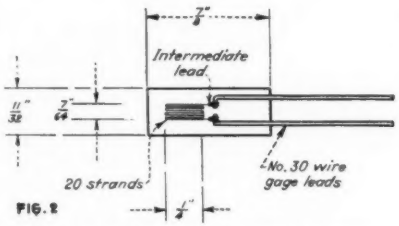


Fig. 2—Dual-Lead Gage. Developed for precision measurements where fatigue resistance, low hysteresis and linearity of strain-resistance ratio are of primary importance. Made in various types and sizes.

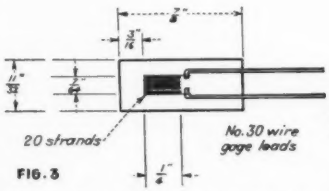


Fig. 3—Typical General-Purpose Gage. Used in locations where space is limited. Available in both nitrocellulose and phenolic resin types and with leads at right angles to grid. Made in various sizes with grid lengths from $\frac{1}{16}$ to $\frac{1}{2}$ inch.

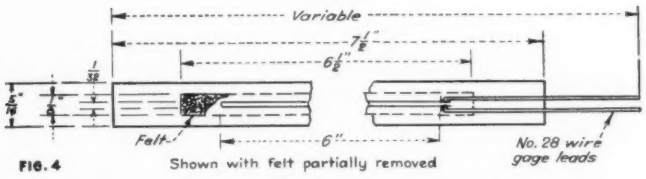


Fig. 4—General-Purpose Gage. Used to measure the average strain over an appreciable distance, as on surfaces subject to elastic buckling or on non-homogeneous materials.

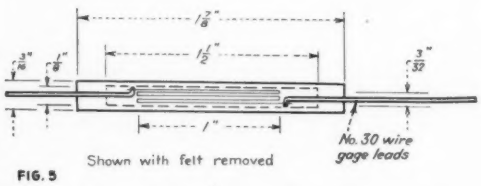


Fig. 5—Typical General-Purpose Gage. For applications requiring an extremely narrow gage of moderate length. A single lead extends from each end. Made in various sizes with grid lengths from $\frac{3}{4}$ to $1\frac{5}{8}$ inches .

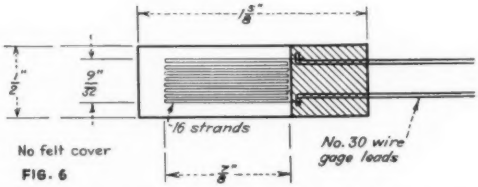


Fig. 6—Typical Resin-Bonded Gage. Used for high temperature and permanent applications. Grid is molded in phenolic resin; special cement and mounting procedure are required. Made in various sizes with gage lengths from $\frac{1}{2}$ to $\frac{7}{8}$ inch.

for Strain Measurements

ARTHUR C. RUGE
Consulting Engineer

GAGE LENGTH. If the stress gradient under study is steep or "sharp" at the point of measurement, a short gage length is used. If the gradient is gradual or local deviations from the mean strain occurring over a wide area do not affect the reading, a gage of greater length is applied. This consideration is relative depending upon the size of the structure being studied.

GAGE SIZE. The size of gages is simply determined by the space available at the points where stresses are to be measured. It is desirable to use one type of gage throughout a single stress analysis project, although some locations will not permit use of the single type. Other gages having closely related electrical characteristics should be used in these locations.

GAGE RESISTANCE. The choice of gage resistance depends on (1) the type of instrumentation to be used, (2) the magnitude of undesirable resistance external to the gage, and (3) the desirability of using series or parallel gage connections, as for example when averaging strains on opposite sides of a test piece.

(B) BIAXIAL STRESSES—directions of axes unknown

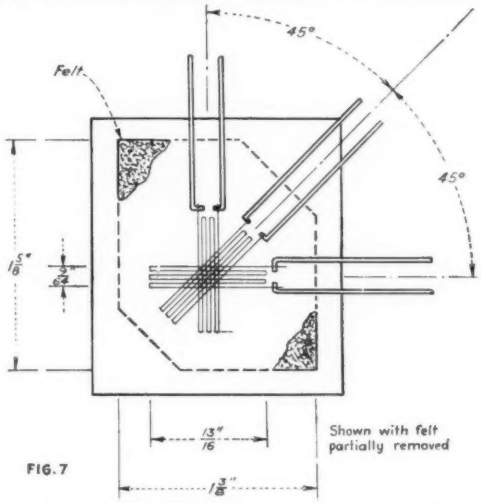


Fig. 7—45-deg Rosette Gage. Comprised of three gages similar to that illustrated in Fig. 1. Made in one size with grid length of $\frac{13}{16}$ inch.

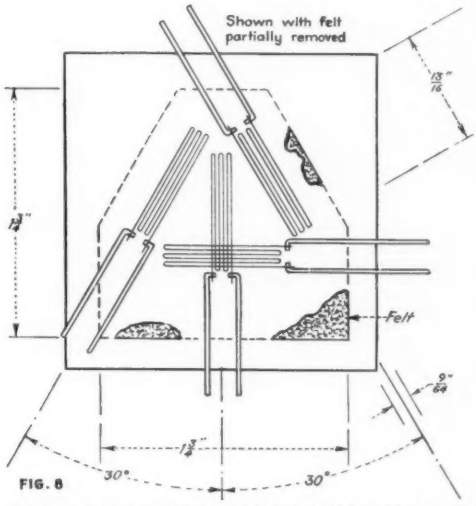


Fig. 8—60-deg Rosette Gage. Choice of this or 45-deg gage (Fig. 7) determined by basic stress calculations used or electrical calculating device available.

(C) BIAXIAL STRESSES—directions of axes known

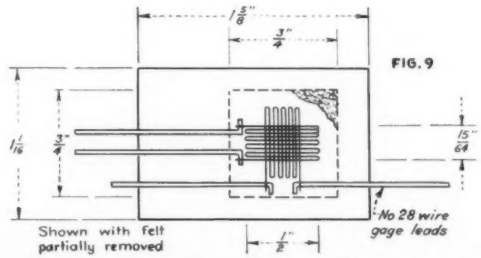


Fig. 9—Two-Element Rosette Gage. Consists of two gages similar to type shown in Fig. 1. Available with grid length of either $\frac{1}{4}$ or $\frac{1}{2}$ inch.

(D) BIAXIAL STRESSES—
one component only to be measured

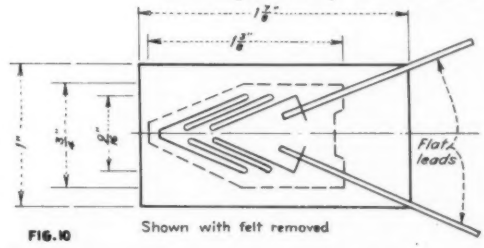


Fig. 10—Stress Gage. Reads stress in direction of its axis and is unaffected by any transverse stress that may exist.

Friction and Wear of Oil-Seal Materials

From Frictional Properties of Oil Seal Materials by P. G. Foroester, *Engineering*, London, England, August 8, 1947.

THE FRICTIONAL PROPERTIES of oil-seal materials are an important factor in their performance. High friction results in large power losses and high local temperatures, and is likely to be associated with high rates of wear. Consequently, an investigation was undertaken to determine the frictional properties of various materials under different operating conditions.

The oil seal materials used were four types of leather ("oak," "chrome," and two Retan leathers, A and B); and two types of synthetic rubber (Neoprene-base and Hycar-base). Three lubricants of standard service grades were used, namely, 30 H.D.—a crankcase lubricant of S.A.E. 30 viscosity containing a detergent and anti-oxidant additives; Hypoid 90—a gear oil with sulphur and chlorine additives and having a viscosity of about 270 Redwood No. 1 sec. at 140 F.; and C.600—a thick gear oil with 10 per cent rape oil, having a viscosity of about 600 Redwood sec. at 140 F. The coefficient of friction is likely to be affected by the following variables: (1) oil-seal material; (2) lubricant; (3) surface finish of mating-steel member; (4) velocity; (5) amount of "running-in"; (6) normal load; (7) temperature; and (8) type of lubrication, pool or film.

Tests were first made on all the materials with 30 H.D. as a lubricant, at room temperature, with a normal load of 2 kg. and with a standard surface finish of the steel specimen. These tests showed that three of the leathers, namely, chrome, Retan A, and Retan B, gave very similar results. The effect of raising the temperature to 100 C. was then examined, for Retan A and Neoprene-base materials. As the effect was found to be considerable, the tests were extended to cover oak, both types of synthetic rubber, and Hypoid 90 as lubricant. The effect of surface finish of the steel was examined for oak, Retan A, and Neoprene-base rubber with 30 H.D. as lubricant and at room temperature.

The majority of the tests were made with both "pool" and "film" lubrication. For "film" lubrication the mating steel specimen was polished with a degreased cloth soaked in the lubricant to be used. For "pool" lubrication the same procedure was adopted, but afterwards sufficient fresh lubricant was added to form a complete pool of lubricant.

The results of experiments at room temperature are shown in Table I. With 30 H.D. as the lubricant, chrome, Retan A and Retan B leathers all behave in a similar manner. Friction rises slightly with increasing velocity. As running-in occurs, the low-speed friction rises sharply, while the high-speed friction also increases slightly. With considerable running-in, the friction falls with increasing velocity over the whole range. With "film" lubrication the behavior is very different. On running-in, the friction is reduced at all but the lowest velocity.

Oak leather behaves similarly, but in this case with a pool of lubricant the low-speed friction rises even more sharply on running-in, while the high-speed friction falls slightly. In general, the synthetic rubbers have much lower coefficients than the leathers and are affected to a far less extent by running-in under "pool" conditions. For Neoprene-base rubber, the friction falls with increasing velocity, reaching low values at the highest velocity; the only effect of running in is to reduce slightly the friction at all velocities. Under "film" conditions the frictional values are similar to those obtained with a pool of lubricant, but on continued running-in there is a large rise in friction. Hycar-base rubber is very similar in its behavior. The only difference is that in this case there is a slight increase instead of a decrease in friction on running-in with a pool of lubricant.

With Hypoid 90 and C.600 as lubricants, the results obtained were similar to those for 30 H.D. The following minor differences concerning the three lubricants appear to be significant: (1) The friction with Hypoid 90 is generally rather lower than with 30 H.D. the only exception being a low-speed run-in value for Retan A, which is slightly higher; (2) the friction with Hycar-base rubber increases on running-in with 30 H.D., but decreases with Hypoid 90, which appears, therefore, to be the better lubricant for this material; (3) the friction with C.600 is lower than with either 30 H.D. or Hypoid 90 in the case of tests with Retan A, and about the same as Hypoid 90 in the tests on Neoprene-base rubber; (4) with C.600, the low-speed

Table I—Coefficients of Friction of Oil-Seal Materials at Room Temperature*

Lubricant	Material of Sliders	Pool of Lubricant				Film of Lubricant			
		Initial		After 160 revs.		Initial		After 160 revs	
		0.05 Cm. per sec.	0.44	0.05 Cm. per sec.	0.44	0.05 Cm. per sec.	0.44	0.05 Cm. per sec.	0.44
30 H.D.	Oak	0.116	0.105	0.201	0.088	0.076	0.090	0.059	0.057
	Chrome	0.085	0.108	0.245	0.129	0.066	0.092	0.069	0.060
	Retan A.	0.084	0.115	0.211	0.152	0.078	0.100	0.067	0.064
	Retan B.	0.074	0.116	0.238	0.156	0.069	0.115	0.067	0.058
	Neoprene-base rubber.	0.093	0.029	0.066	0.019	0.072	0.025	0.104	0.072
	Hycar-base rubber.	0.076	0.029	0.124	0.033	0.092	0.049	0.130	0.058
Hypoid 90.	Oak	0.056	0.074	0.163	0.059	0.080	0.093	0.066	0.057
	Retan A.	0.079	0.102	0.199	0.092	0.055	0.081	0.054	0.053
	Neoprene-base rubber.	0.050	0.020	0.038	0.013	—	—	—	—
	Hycar-base rubber.	0.093	0.035	0.072	0.016	—	—	—	—
C.600	Retan A.	0.066	0.080	0.122	0.085	0.063	0.069	0.047	0.042
	Neoprene-base rubber.	0.030	0.020	0.028	0.014	0.033	0.017	0.059	0.059

*Temperature 18 C. Figures represent the means of two determinations.

Table II—Coefficients of Friction of Oil-Seal Materials at 100 C.*

Lubricant	Material of Sliders	Pool of Lubricant				Film of Lubricant			
		Initial		After 160 revs.		Initial		After 160 revs.	
		0.05 Cm. per sec.	0.44 Cm. per sec.	0.05 Cm. per sec.	0.44 Cm. per sec.	0.05 Cm. per sec.	0.44 Cm. per sec.	0.05 Cm. per sec.	0.44 Cm. per sec.
30 H.D.	Oak	0.148	0.134	0.111	0.158	0.127	0.113	0.119	0.077
	Retan A	0.127	0.106	0.126	0.142	0.138	0.112	0.118	0.090
	Neoprene-base rubber	0.073*	0.135*	0.093*	0.117*	—	—	—	—
	Hycar-base rubber	0.086*	0.111*	0.117*	0.155*	0.095	0.084	0.145	0.172
Hypoid 90	Retan A	0.140	0.121	0.215	0.155	—	—	—	—
	Hycar-base rubber	0.164*	0.181*	0.142*	0.147*	—	—	—	—

*Figures represent mean of two determinations, except those marked with an asterisk, which are the mean of four determinations.

friction of Retan A increases much less than with 30 H.D. or Hypoid 90 on running-in with a pool of lubricant.

The results of these tests at 100 C. are shown in Table II. With both leathers and 30 H.D. as lubricant the friction with fresh surfaces is of the same order as at room temperature. Running-in with a pool of lubricant has, however, a more adverse effect than at room temperature. The high-speed friction is increased and the friction-velocity curve develops a slight upward slope, implying that still higher values of the coefficient may be expected at velocities above the test range. The low-speed friction is reduced by running-in (in contrast with the rise observed at room temperature), but this advantage is outweighed by the increase in the high-speed friction. With a pool of Hypoid 90, running-in increases the friction at all velocities, but the curve of friction vs. speed does not develop an upward slope. With a film of lubricant the effect of running-in on the leathers is similar to that at room temperature i.e., there is a general slight fall in friction.

With the synthetic rubbers, the friction at the higher velocities is always much higher than at room-temperature; further, friction-velocity curves all show an increase in friction with increasing velocity, implying that still higher values would be found at velocities beyond the test range. The actual values of the coefficient recorded are inconsistent, and accordingly four tests were made on both the Hycar-base and the Neoprene-base rubbers. The results of the four tests on Hycar-base lubricant indicate that the value of the high-speed friction coefficient after running-in varies from about 0.09 to 0.23. At intermediate stages of running-in, even higher values were recorded. The Neoprene-base rubber also gave high values of the coefficient, although these were less variable than with the Hycar-base lubricant.

The effect of surface finish of the mild-steel specimen was examined for oak and Retan A leather and for Neoprene-base rubber. Four different types of surface finish were used: (1) Circumferentially machined, the last cut being as fine as possible; (2) circumferentially ground with 0 emery cloth (the standard preparation); (3) radially ground with 0 emery cloth (by hand); (4) polished with successively finer emery papers, then metal polish, and finally alumina in distilled water. The arithmetical average values of the surface roughness of the plates are given in Table III.

Examination of the profile records showed that the machined and emery-ground surface did not differ greatly in their surface profile, except in the fineness of the finishing marks. The polished surface was entirely different from the other three, showing a series of undulations of relatively long wave length with little evidence of any micro-roughness.

The effect of changing the finish is to change the general level of the coefficient without greatly influencing either the shape of the friction-velocity curves or the changes that take place on running-in. Of the materials tested, the effect of surface finish was greatest for Neoprene-base rubber and least for Retan A. With Retan A the observed differences were barely significant. With oak and synthetic rubber the surface finishes were in the same order, namely, polished, circumferentially emery-ground, machined and radially emery-ground in order of increasing coefficient. The main conclusions are that the coefficient of friction of the synthetic rubber is much more sensitive to surface finish than that of the leathers, and that the direction of the finishing marks is more important than their depth. It may also be significant that the harder of the two leathers was the one less affected in its frictional properties by change of surface finish.

Table III

Preparation	Direction of Instrument Traverse	Meter Reading (micro-in.)
Machined	Radial	53
Circumferential, O Emery	Radial	5.5
Radial, O Emery	Circumferential	12.5
Polished	Radial	3.0

Under conditions where high coefficients were observed, a considerable amount of wear of the sliders occurred, and a large number of black specks were visible on the plate. The conditions leading to considerable wear were: (1) "film" lubrication with all lubricants; (2) temperature of 100 C., especially in the case of Hycar-base rubber; and (3) machined and radially emery-ground surface finish.

From the work which has been described the following conclusions were reached. (1) On the evidence of the room-temperature tests the three leathers chrome, Retan A and Retan B do not differ significantly in their frictional properties. Oak leather shows exactly the same type of behavior, but under the standard conditions there is a tendency for its frictional coefficient to be lower. (2) With fresh surfaces, the friction of the leathers is of the same order at 100 C. as at room temperature. (3) The frictional properties of the leathers are to some extent impaired by running-in with an excess of lubricant. At room temperature, the effect is largely confined to the low-velocity end of the test range and so is of limited practical importance, except in so far as it may favor the occurrence of stick-slip oscillations of the seal. At 100 C. the friction at higher velocities is increased, an effect which may be very significant. Thus, paucity of lubricant has a favorable effect upon the friction of the leathers. (4) The leathers are not very sensitive to the surface finish of the mating steel part, although oak is more so than Retan. (5) At room temperature, with excess lubrication, the synthetic rubbers have lower coefficients of friction than the leathers. This difference is nullified or reversed when the temperature is raised to 100 C., when the supply of lubricant is

sparse, or when the steel surface is rough or has markings perpendicular to the rubbing direction. In all these circumstances, the frictional properties of the synthetic rubbers are definitely poor.

This work was carried out in the laboratories of the Tin Research Institute and formed part of a research program which was undertaken for the Joint Admiralty and Ministry of Supply Advisory Service on Lubrication and financed by the Ministry of Supply.

Adhesives as Engineering Materials

From "Engineering With Adhesives" by J. O. Hendricks, G. F. Lindner and F. J. Wehmer, Minnesota Mining and Manufacturing Company, presented at the Chicago Rubber Group meeting on March 24, 1948.

SINCE an adhesive is always used with other materials, it is important that the total structure be designed correctly, especially since adhesives are used with rigid materials as well as flexible materials. Stresses that range from pure tensile to pure shear, and in almost any combination, are encountered. When bonding materials with widely different coefficients of expansion, correct design will minimize the stresses caused by expansion and contraction with change in temperature. Much can also be done by choosing the correct adhesive. For example, some adhesives are better in shear; the part should then be designed to put the largest part of the stress in shear.

Adhesives can be divided into these arbitrary classes:

1. Starch pastes and gums.
2. Animal or fish glues—vegetable protein adhesives.
3. Natural resin adhesives.
4. Inorganic adhesives.
5. Thermoplastic and thermosetting resins.
6. Rubber and synthetic rubber.

Combinations of the various groups can be made; this indicates the complex problem of using adhesives intelligently. Adhesives are available to the user in the following forms:

1. Water dispersed adhesives.
2. Solvent dispersed adhesives.
3. Adhesive film on carriers.
4. Unsupported film adhesives.

Latex compounds and emulsions of adhesives and pastes are examples of water dispersed adhesives. Solvent dispersed adhesives are the most familiar type. Tapes are sometimes activated by heat and pressure. Unsupported film adhesives are best activated by the use of heat and pressure.

Water or solvent dispersed adhesives can usually be applied by brushing; this is effective on small areas. Where large amounts of adhesive must be applied, or if a specific thickness of adhesive is required, other methods of application must be used. Where the adhesive is of the proper consistency it may be applied by knife or "doctor blade". Many people also apply adhesives from pick up rolls which run a reservoir of the adhesive. These two methods work well for flat surfaces.

Irregular surfaces are best bonded by spraying the adhesive. With heavy duty pumps it is possible to spray heavy material. Adhesives can also be flowed through a hose and there dropped on the material. A brush can be added to a setup of this kind and the material is applied and brushed at the same time. An example of this type of application is on the adhering of weatherstrip rubber to automobile car doors.

When the adhesive is used as a tape there are several methods of application: the tape can be activated by machine, with solvent or water and thus rolled or brushed in place. Where a pressure sensitive adhesive is used, this activation is not necessary. Unsupported film adhesives are usually cut to required size, put in place, and heat and pressure are applied to set.

If an adhesive in a vehicle is used between surfaces which do not allow the vehicle to escape, poor adhesion will be obtained. If creep is of importance, a thin film of adhesive will do the best job. Surfaces to be adhered should be clean, since the adhesive will adhere to foreign matter on the bonding surface and pull it away. Thin films of oil can seriously interfere with adhesion. On metals scales or oxides interfere with adhesion. It is possible to clean by giving the surface a light scuffling with coated abrasive paper or a wire brush, or by vapor or sand blasting. Surface can also be cleaned with solvents. Another method is to etch the surface of metals by the use of proper reagents. These must then be removed and the surface must be dried before the adhesive is applied.

The problem of strength tests of adhesives is a difficult one. On adhesives that have a tendency to cold flow or creep, it is not enough to measure strength with a tensile testing machine but it is also necessary to test under static loads. An adhesive with high strength values, when pulled apart at a rate of two in. per min. can fail when continuously loaded with much lower stress.

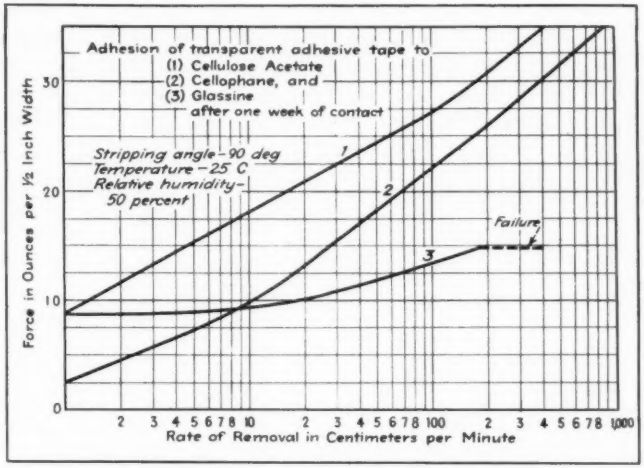
Results of tests conducted by the Minnesota Mining and Manufacturing Co. on adhesion of adhesive tape to various surfaces are given in ounces per ½ in. width after 24 hr. contact. The rate of stripping is 100 cm per min—stripping angle 90 deg, temperature 25 C, relative humidity 50 percent:

Cellophane	21
Cellulose Acetate (2 mil commercial film)	25
Nitrocellulose (commercial film)	13 (increasing)
Vinyl chloride—vinyl acetate copolymer (commercial film, unplasticized)	23
Polystyrene (coated on paper, unplasticized)	17 (increasing)
Paper (Permanized Artesian Ledger)	17 (increasing)
Glassine	12 (increasing)
Steel	19 (increasing)
Chromium plate	24
Nickel plate	18
Silver plate	20
Brass plate	18
Aluminum	19
Glass	25
Automotive Enamel	25
Automotive Lacquer	25

In the accompanying graph force is plotted in ounces per ½ in. width against rate of removal in centimeters per min. for transparent tape on cellulose acetate, cellophane and glassine. These results show that a given adhesive gives different results when stripped from different surfaces. Also, the maximum value of adhesion is not reached in 24 hours of contact.

The graph shows that the rate of removal has a marked influence on the values and that the change with rate of removal is different for different surfaces. At low rate of removal cellulose acetate and glassine are nearly equal. At higher rates of removal the value on cellulose acetate increases rapidly while the value on glassine increases only slightly. At low rates cellophane has a very low value but it increases rapidly to a high value.

It is difficult to predict how an adhesive will behave under all possible conditions. It is often necessary to test adhesives against the type of surface and as nearly under use conditions as possible. For instance, it is not pos-



sible to recommend an adhesive for all types of vinyl films simply because it works on one type of vinyl film.

Increasing applications of adhesives are found in the automotive industry. With the use of the all metal body it became necessary to cut down on the rumbling noise which occurs when the car is driven over a rough surface. One way of accomplishing this is to adhere a pad into the roof of the car.

The adhesive which best answers this use is a low cost material dispersed in a non-inflammable vehicle, since it is used where welding or drilling of metal is being done. It must have high heat resistance, and must not lose adhesion under very humid or wet conditions, since it may have to go through the bonderizing process. It must have high strength while wet since the pads must be installed before the adhesive has an opportunity to gain strength.

Another automotive problem is adhering weatherstrip rubber to the body, and to obtain good adhesion to lacquer and weatherstrip rubber and retain the application characteristics needed. A special problem encountered is the fact that the weatherstrip often contains a large amount of plasticizer which reacts with the adhesive making it soften and lose strength. This type of adhesive must have good life aging, should be strong and have high heat resistance.

Adhesives for bonding brake lining or blocks to brake shoes are replacing rivets. This construction does away with rivet holes and makes it possible to use the lining for a longer time. Some of the danger of scoring brake drums is eliminated since the rivet holes which collect debris and the rivets are no longer there to score the drum.

Adhesives are being used to laminate metal skins to light weight cores, such as end grain balsa or honeycomb resin-impregnated papers and give structures which are light and strong. The lamination of metal to wood gives structures which have most of the advantages of both materials. These panels are being used by the transportation industry where they fill a need in giving a decorative panel with good strength.

Adhesives with very high strength have been developed. On metal to metal bonds, values as high as 4000 psi have been obtained. These allow designers freedom to accomplish results which might not be possible through the use of rivets or other fasteners. However, a method of testing adhesive bonds without ruining the structure should be developed.

Stabilization of Austenitic Stainless Steel

From "Stabilization of Austenitic Stainless Steel" by S. J. Rosenberg and J. H. Darr; *Journal of Research of the National Bureau of Standards*, Research Paper RP1878, Volume 40, April 1948.

DATA are presented on the resistance to intergranular embrittlement of 23 austenitic corrosion-resisting steels (18 percent Cr—10 percent Ni base composition) in 12 different initial conditions. Susceptibility to intergranular attack was determined after seven different sensitizing treatments, followed by a maximum of 14 days exposure in a boiling acidified copper sulfate solution. The following conclusions appear warranted:

1. Of the various sensitizing treatments utilized, maximum susceptibility to intergranular attack was developed by either 8 or 21 days at 1,020 F. The commonly used sensitizing treatment of 2 hours at 1,200 F was ineffective in developing susceptibility in any but the most vulnerable steels.

2. The straight carbon austenitic corrosion-resisting steels were very susceptible to intergranular embrittlement. The susceptibility decreased as the carbon content decreased but, with the exception of one low-carbon steel in the cold-rolled conditions only, even the very low carbon steels (0.025 percent C) were vulnerable regardless of heat-treatment.

3. In the columbium-and titanium-bearing steels, carbon content within the range of 0.06 to 0.13 percent had no influence upon the resistance to intergranular attack, except insofar as it influenced the Cb/C or Ti/C ratios. Steels having similar ratios of stabilizing element to carbon had approximately the same degree of susceptibility to intergranular attack regardless of the carbon content.

4. Both the columbium-and titanium-treated steels exhibited greater resistance to intergranular attack as cold rolled or annealed at 1,800 F and water quenched than as annealed at 1,800 F and air cooled, or as annealed at 1,975 F and either water quenched or air cooled.

5. Stabilizing heat-treatments at 1,600 F had a neglibible effect upon the resistance to intergranular embrittlement of the columbium-treated steels. The performance of the titanium-treated steels carrying the higher ratios of Ti/C, however, was markedly improved by such treatments. Variation in time of the stabilizing treatments from ½ to 2 hours had no effect.

6. When properly treated, substantially complete immunity to intergranular attack may be obtained with a minimum ratio of Cb/C equals 10 and Ti/C equals 5. For more "foolproof" immunity, it is believed that these ratios should be 12 and 8 respectively.

It should be emphasized that the data and conclusions given in this paper refer only to the susceptibility of the test steels to intergranular attack as developed under test conditions considerably more severe than those normally used.

TECHNICAL NEWS

ENGINEERING MILESTONE—Representatives of the U. S., Britain and Canada gathered to sign unified screw thread accord. Signers were Sir Ewart Smith, British industrialist; E. U. Condon, U. S. Screw Thread Comm.; C. D. Howe, Minister of Trade, Canada; J. G. Morrow, Canadian Standards Assn.; T. R. B. Sanders, Ministry of Supply, United Kingdom; Percy Good, British Standards Institution; F. P. Tisch, American Standards Assn.; and W. L. Batt, Sponsors Council, United States and Britain.

International Unified Screw Thread Accord Signed

AN INTERNATIONAL standardization program of major importance to industries using bolts, nuts, screws, and other threaded components reached a successful conclusion on November 18 at the National Bureau of Standards in Washington, when delegates of industry and government from the United States, the United Kingdom and Canada signed an accord establishing a Unified Screw Thread Standard.

The accord affirms the unification represented in the publications of the Interdepartmental Screw Thread Committee of the United States (representing the Departments of Army, Navy, Air Force and Commerce) and of the British Standards Institution the Canadian Standards Association, and the American Standards Association. These documents fulfill all of the basic requirements for general interchangeability of threaded products made in the Nations. The accord also represents the culmination of 30 years of intermittent efforts among the three Nations and signifies the continuance of future cooperation in development and extension of these standards.

Technical Aspects

The three principal characteristics of screw threads are angle and form of thread, the number of threads per inch for the various series of thread diameters, and the tolerances and allowances for the three classes of fits.

The British system, originated by Whitworth in 1845, is based on a thread angle of 55 deg with a thread form having rounded crests and roots. The American system, developed by Sellers in 1864, has a thread angle of 60 deg with a thread form having flat crests and roots. The number of threads per inch for the various series of thread diameters was the same in both systems (with the exception of the half-inch coarse thread), but the tolerances and allowances varied.

The present unification agreement provides a 60 deg angle and a rounded root for screw threads. The crest of the thread may be flat, as preferred in American practice or rounded as preferred by the British. The number of threads per inch for the various series of thread diameters has been unified, and the limiting dimensions for three classes of fit have been agreed upon. Thus, interchangeability of screw thread parts, based on the accord, now becomes feasible.

The importance of the unification rests largely on the need for interchangeability of parts of manufactured products if trade and commerce are to be developed fully among the three Nations.

In the past, one of the irksome aspects of international trade has been the necessity for supplying and distributing screw thread parts associated with equipment sold by one nation to another. Furthermore, the question of the availability of such parts has acted as a psychological deterrent on purchasers from other Nations.

Production bottlenecks have also arisen from time to time. This problem became acute during World War II when the English Rolls Royce aircraft engine was to be produced in America by the Packard Motor Car Co. The difficulties encountered were fully discussed in an article entitled "Why Packard Made New Drawings for the Rolls Royce Merlin Engine" (PRODUCT ENGINEERING, November 1946.

Background

The Unified Screw Thread Standard was formulated in five major and several informal conferences of representatives of the countries concerned. In July, 1918, the Congress of the United States authorized the appointment of the National Screw Thread Commission, with the Director of the Na-

tional Bureau of Standards as chairman, to investigate and promulgate standards for screw threads. One year later, and after a thorough study of screw thread practice in this country, the Commission conferred with British and French engineers and manufacturers of screw thread products, for the purpose of discussing the tentative report which it had prepared with the hope that it might serve as a basis for international standardization. No definite agreements were reached, but the need for continued study was recognized. In 1926, a British mission visited the United States. Specific proposals on unification were discussed, but no agreements were reached.

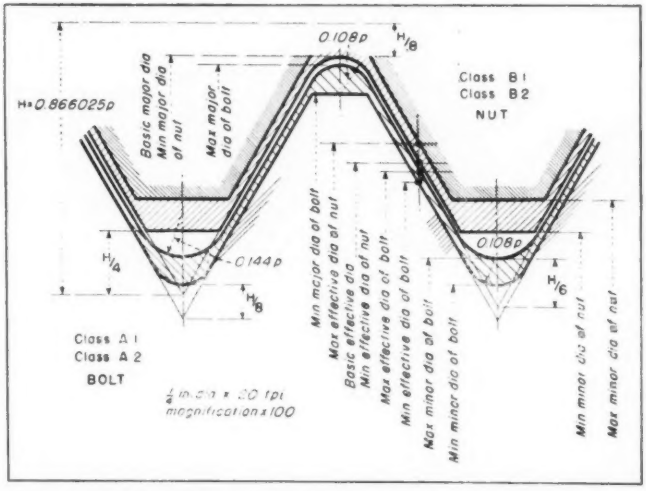
In 1943, a British mission and Canadian representatives visited the United States at the invitation of the Combined Production and Resources Board. Notable progress was made on projects of immediate concern. In August-September 1945, a conference on Unification of Engineering Standards was held in Ottawa, Canada. At this conference a unified form of thread having a 60 deg angle, together with standard sizes and pitches, was agreed upon. Thus the foundation was laid for the standards to be agreed on, but a vast amount of work remained to be done in developing and agreeing upon classes or grades of fit and corresponding tolerances.

When a small British delegation visited the United States in July 1948, basic mathematical formulas for such tolerances and allowances were tentatively agreed upon and later ratified by correspondence, thus making possible the completion of the standards agreed upon, as signified by the November 18th signing.

Future Developments

In one sense, the present accord marks the culmination of thirty years of work by the three Nations toward the establishment of unification. In another sense, the accord marks the beginning of the realization of the unification. Purchases by the three governments will be based on the new standards, but industrial use within the normal commerce of each of the nations will require a transformation of industrial practices, involving considerations of engineering, design, tooling and production. Such a change will take time, but the transition should be completed in the next few years.

The present accord pertains to the most commonly used type of screw thread. Other important types of screw threads, such as the buttress and the acme, remain to be standardized. Further, standardization of drawing room practices within the countries and their unification among the countries are essential if there is to be a thorough understanding by each country of the production drawings of the others. In these and related fields, the three Governments and the respective standardization organizations are carrying on continuing programs.



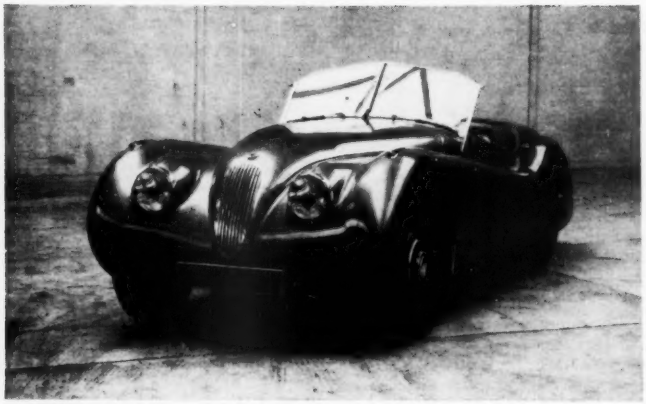
THE AMERICAN-BRITISH-CANADIAN Unified Screw Thread Standards provide for the interchangeability of American and British threaded parts. Diagram shows American preferred form of internal thread (above) with flat crests and roots, unified external thread form (center) with rounded roots and either rounded or flat crests and British preferred form (below) with rounded root and flat crest.

British Cars and Trucks Keyed for Export

BRITAIN'S automobile industry was on parade at the world's two largest motor shows—The Commercial Motor Transport Exhibition (Oct. 1-9) and the International Motor Show (Oct. 27-Nov. 6), both being held in London for the first time since before the War. Keynote of both shows was exports. During the past year, the motor industry has jumped into first place in Britain's export drive, and ranks as the country's third largest producer. Shortage of key materials, especially steel, is holding output down to about 60 percent of the industry's capacity. But still some 1,000 passenger cars roll off British assembly lines every working day.

The 1949 passenger cars represent a break from former British styles. In overall design, the chief new features are the increased strength of the chassis and the predominance of higher-powered engines. With the exception of Nuffield's Morris "Minor" (31 bhp), all new cars of the "Big Six" manufacturers (Nuffield, Rootes, Austin, Ford, Standard, Vauxhall) have increased engine power without adding weight. This has been accomplished through the use of shorter wheelbases, lighter and stiffer frames, and—in a few cases—by incorporating the body and chassis into one unit. Other improvements in new British models include: Independent front wheel suspension by coil or transverse springs or torsion bars, half-elliptics at the rear, and box frames; more streamlined body styles with sealed-beam headlights, lights in fenders or tight against hood, recessed door handles, less radiator, more grille and flat floors having no propeller shaft tunnel; steering wheel gear control; power-operated hoods and windows; higher ground clearance; and new "puncture-proof" tires.

Outstanding among the new models are: (1) Standard's "Vanguard" (Standard Motor Co., Ltd., Coventry). Four-cylinder overhead valve engine rated at 68 bhp; bonderized body and chassis with 7 ft, 10 in. wheelbase; and independent front suspension with coil springs controlled by hydraulic dampers. (2) Vauxhall's "Velox" and "Wyvern" (Vauxhall Motors Ltd., Luton, Bedfordshire). Velox-6-cylinder engine rated at 54 bhp and Wyvern-4-cylinder power plant rated at 35 bhp; horizontal radiator grilles and streamlined extensions to front and rear fenders. Both cars have special Vauxhall system of 6-phase carburetion that incorporates a part-throttle



TYPE XK Jaguar "120" sports roadster drew considerable attention at the International Motor Show recently held in London. Body is aluminum on a laminated frame. Six-cylinder 70-deg Vee, twin-overhead camshaft engine is rated 160 bhp at 5,000 rpm.

economy device and an accelerator pump; (3) Rootes Group's "Sunbeam-Talbot" (Sunbeam Talbot Ltd., Ryton-on-Dunsmore, Warwickshire). Sports car with overhead valve engine in two sizes (47 and 64 bhp), four-speed transmission with control lever on steering column. New safety feature is an opticurve windshield that cuts out dazzle by day and glare by night, and allows door pillars to be set back to avoid blindspots. Driving seats adjust up and down as well as backwards and forwards. Entirely new car of conventional appearance but unusual engine (51 bhp), will be in full production by mid 1949. Interesting feature is a thermostat attachment that insures rapid heating of oil as water circulates in cylinder head, then cuts off water and permits oil to cool. Transmission is separated from engine, making possible a short final drive propeller shaft.

Half a million trucks, buses and utility vehicles have come off British assembly lines since the War whereas only 15 percent of British-made commercial vehicles were exported before the war. 50 percent are now being shipped abroad. Most of them range from 1- to 6-ton carrying capacity.

Modern streamlined design for heavy British vehicles made its first big splash. Many of the new products have a decidedly American appearance. Streamlining is particularly noticeable in the newer buses, many of which have been made to order for overseas customers and were exhibited at the Show with foreign company names already painted on their bodies for operators in Egypt, Argentina, Nigeria and dozens of other countries. Ultra-modern bus interiors are also keeping pace with recent American developments. Many British companies now offer adjustable seats, as well as controlled ventilation and thermostatically controlled heating.

British bus design is moving steadily toward horizontal placement of engines. Leyland Motors Ltd. is the latest company to turn its engines on their sides and to seat the driver above the power unit. Sentinel Ltd. (Shrewsbury) have designed a new diesel engine for under-floor installation both in buses and in trucks. All working parts are entirely enclosed, yet readily accessible in the under-floor mounting.

Probably the most marked technical improvements in bus chassis design have been made to diesel engine and transmission units. Diesel engines are now used universally in British-made heavy chassis, and are being installed more and more in 5- and 7-ton trucks.

Some new heavy truck cabs have emerged with all the comforts of a private car. Chief provisions for reducing driver fatigue include radio sets, better ventilation and power-boosted controls. One highlight was a big Daimler bus chassis fitted with a complete set of power-assisted controls similar to those perfected during the War for heavy armored vehicles. The chassis, termed the CD650, is an 8-ft-wide model designed for overseas use in double-deck buses seating 56 passengers. The 650 direct-injection oil engine has a capacity of 10.6 liters and maximum bhp of 123 at 1,700 rpm. With the aid of a Lockheed hydraulic system working at pressures up to 1,000 psi, the effort needed to turn the steering wheels, to declutch or to brake by hand or foot is greatly reduced. This model also has a fluid flywheel and a preselector epicyclic transmission with four forward speeds.

Crossley Motors Ltd. has come out with the first production-model supercharged engine, an 8.6 liter diesel. It is used as the standard power unit for a range of Crossley buses, including a new double-deck model incorporating a single-pedal-control turbo-transmitter that adjusts itself automatically to the load and speed of the vehicle. Apart from the brake, the accelerator is the only control pedal, governing both start and pick-up.

With a strong accent on exports, Albion Motors Ltd. Motor Exhibition displayed two buses that have been especially designed for foreign markets. Both feature a straight-frame chassis with overhead worm drives to give maximum ground clearance. The smaller bus is powered by an 80 hp 6-cylinder Albion gasoline engine, and is fitted with a 4-speed transmission and long flexible springs. The insulated body incorporates a double-skinned roof with air stream between skins to provide maximum protection against tropical heat. Albion's larger bus is built to an overall length of 36 ft and a width of 8 ft. The chassis has a wheelbase of 22 ft, 6 in. powered by a 6-cylinder 175 bhp gasoline engine with twin carburetors. Body features include pneumatically operated front and rear doors, special air-conditioning equipment and a public address and radio system.

Twistless Sewing Thread Does Not Split or Ravel

MONOCORD is a multi-filament thread that is neither coated nor resin-treated. It is made up of fibers that are "welded" together. In conventional thread, the fibers are twisted together. Big advantage of Monocord, according to Belding Corticelli, is that it will not kink, snarl, split or ravel. It can be made from almost any fiber, will work just as easily on a home sewing machine as it will on big industrial equipment.

A nylon thread, called Nymo, is the first to be made under the Monocord process. Cost will be about the same as that for twisted-nylon thread, but full-scale commercial production is a good way off.

One point must still be worked out: Finding dyestuffs that will take the high welding temperatures.

Washington Notes

Turbojet Operated With "Cold" Blades

Navy and National Advisory Committee for Aeronautics observers have shown interest in a turbojet engine in which turbine blades, cherry red at the start of operation, turn black as speed is increased to 20,000 rpm and higher.

A demonstration was made to display combustion characteristics of a new turbojet burner designed by John C. Hawkins of Skyhawk Motors, Inc., North Hollywood, California. Hawkins claims his design results in nearly-complete combustion of fuel within the combustor and delivery of gases to the turbine wheel area at reduced temperatures, yet with little or no loss of mass flow and velocity.

Engineers who have seen the engine run insist that merit of his system will hinge largely upon measurements of thrust and fuel consumption after an efficient tail cone, now being developed, has been attached to the engine.

During test runs, the engine showed an unusually smooth start upon ignition at 4,000 rpm. Turbine blades quickly glowed cherry red, and then, as speed went beyond 8,000 rpm, "chilled" and turned black. No heat colors could be observed through advancing speeds.

Externally, the Hawkins combustor varies from the conventional circular turbojet burner in that it is an extended rectangular box of stainless steel. The inventor has not disclosed its interior details of fuel mixing and ignition.

Central Air Documents Office Set Up by Navy and Air Force

Joint operation by the Navy and Air Force of a central documentary service for the collection, publication and dissemination of air-technical information was recently announced.

The new Central Air Documents Office at Wright-Patterson Air Force Base, Dayton, Ohio, formalizes a working arrangement between the Air Force Air Materiel Command and the Navy's Bureau of Aeronautics. Its major policies are determined by the Research and Development Board of the National Military Establishment.

USAF Announces Formation Of Research Corporation

An independent research organization, known as the Rand Corporation, has been established at Santa Monica, California to conduct a new type of scientific research and analysis. At the present time Rand is working on problems of importance to the United States Air Force.

In broadest terms, the purpose of Rand is to apply the nation's best scientific abilities and achievements to the objective or providing the greatest amount of national security for the least expenditure of men, money and materials.

The Corporation has been set up as a private non-profit enterprise, governed by a Board of Trustees drawn from leaders of science and industry. The present work of the organization is being carried on under a contract with the Air Force and its operations in the future may be performed for other governmental agencies on a research contract basis.

The organization was set up in this manner in an effort to create a form of

Official U. S. Navy Photograph

Navy Demonstrates New "Flying Wing" Fighter

A NEW NAVY swept-wing jet fighter designed for carrier operation has successfully completed its initial flight tests at the Naval Air Test Center, Patuxent River, Maryland.

The tailless XF7U-1 developed by Chance Vaught is in reality a flying wing. Incorporation of the sweep-back of the wings with a twin-engine installation, makes the fighter potentially capable of speeds in excess of current models of operational jets, land or carrier based. It is rated in the "over 600 mile an hour class".

The unconventional appearing airplane has two vertical stabilizers and rudders located at the trailing edge of the wing. Longitudinal and lateral control are obtained through the use of a pair of "ailevators," or combined ailerons and elevators, that are actuated by a hydraulic boost system of controls.

The XF7U-1 has no landing flaps. To achieve the relatively low speeds necessary for landing aboard carriers, the airplane is equipped with leading edge flaps. The extension of these flaps during a landing approach increases the wing lift and delays the stalling point. For aerial maneuvers as well as landing operations, brakes are located at the trailing edge of the wings for reducing speed rapidly.

Powerplants are Westinghouse turbo jets. For combat performance, high bursts of power can be obtained through after-burners, thereby obtaining large increases in thrust for short periods. The air intake ducts are at the roots in the leading edges of the wings.

Another feature of the plane is the use of magnesium in certain areas instead of the usual aluminum alloy covering. Although magnesium has been used in other aircraft, the XF7U-1 has used more of this material than other craft. This has resulted in a considerable decrease in weight.

The pilot's seat is of the ejectable type for bailing out at high speeds. Both the pilot and the seat are ejected from the airplane at a velocity calculated to clear all parts of the aircraft structure. In the final descent the seat is jettisoned for a normal landing.

research organization that would meet three basic requirements: (1) to permit the highest type of scientific research in conjunction with the best industrial experience and knowledge; (2) to give scientists the greatest freedom of initiative and yet provide the high degree of administrative responsibility necessary for work in highly classified fields, and (3) to enable civilian scientists to work under civilian control and yet in the closest cooperation with the military.

Airplanes with Adjustable Wing Predicted

MILITARY and commercial airplanes that will adjust their wings in flight for either supersonic or subsonic speeds were predicted by Smith J. De France, director of the National Advisory Committee for Aeronautics' Ames Laboratory for Aerodynamic Research.

Mr. De France told a group of aviation writers touring west coast aircraft plants under auspices of the Air Force and the Aircraft Industries Association, that necessary scientific data for construction of such craft "already are in hand."

Only the mechanical application of these established principles remains to be worked out by plane designers and builders, he added, saying that this posed an engineering problem relatively no more difficult than a retractable landing gear would have been considered twenty years ago.

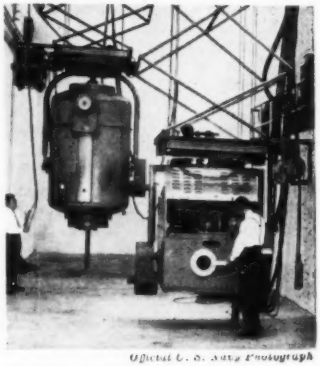
Investigations carried out in subsonic and supersonic wind tunnels have established that the conventional straight-winged airplane gives the best all-around performance at sea-level speeds up to 600 miles an hour. Beyond that range, beneficial results are obtained by sweeping back the wings in an arrowhead pattern, which reduces drag and makes it possible to attain approximately twice the speed of sound with normal power increases from engines of a type that are already available.

Bearing and Lubricants Center Established

THE General Electric Company has recently established a bearing and lubricants center at Schenectady, N. Y. Studies will deal with rolling-contact bearings, sleeve bearings and bearing materials, as well as their lubricants.

Much of the apparatus had to be designed for this work. To date, the most useful piece of equipment has been the compatability tester. This measures the ability of a metal to run on a journal material under controlled test conditions during which the amount of scuffing, welding and metal pick-up on the journal bearing are studied.

Temperature rise, variations in the coefficient of friction and rate of wear as determined from surface roughness measurements made on a Brush Analyzer are also used in evaluating bearing characteristics.



Official U. S. Navy Photograph

Mobile Betatron Will Aid Navy Research

THE WORLD'S first mobile betatron, a 10-million-volt X-ray generator whose rays are capable of penetrating 16 in. of steel, is being installed at the Naval Ordnance Laboratory, White Oak, Maryland. Built for the Navy Bureau of Ordnance by the General Electric Company's General Engineering and Consulting Laboratory at Schenectady, N. Y., machine will be placed in operation early this year. The massive betatron, first industrial machine whose rays will penetrate steel thicker than 12 in., is remarkable in that it can be aimed in any direction, whereas all other betratrons, cyclotrons and similar nuclear research equipment of this type are held in a fixed position. It will be used at White Oak principally for studying the complex internal assemblies of mines, torpedoes, and other items of Naval ordnance.

Special Propellers Permit "Braking" of Large Planes

THE CURTISS-WRIGHT CORP. recently demonstrated to military, airline and government officials how reversible propellers can enable multi-engine aircraft to descend safely at rates exceeding 10,000 fpm with air speeds below 200 mph. The experiment involved reversing the thrust of all propellers during flight, making it possible to more

MEETINGS

January 10-12
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Conference on High Frequency Measurements, Washington, D. C.

January 10-14
SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Engineering Display, Book-Cadillac Hotel, Detroit, Mich.

January 10-14
MATERIALS HANDLING INSTITUTE—Materials Handling Show, Convention Hall, Philadelphia, Pa.

January 12-14
SOCIETY OF THE PLASTICS INDUSTRY, REINFORCED PLASTICS DIV.—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

January 19-21
SOCIETY OF PLASTICS ENGINEERS—Annual Meeting, Bellevue-Stratford Hotel, Philadelphia, Pa.

January 19-22
AMERICAN SOCIETY OF CIVIL ENGINEERS—Annual Meeting, Hotel Commodore, New York, N. Y.

January 24-27
INSTITUTE OF THE AERONAUTICAL SCIENCES—Seventh Annual Meeting, Hotel Astor, New York, N. Y.

January 24-28
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—Ninth International Heating and Ventilating Exposition, International Ampitheater, Chicago, Ill.

January 31-February 4
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—General Meeting, Hotel Pennsylvania, New York.

February 28-March 4
AMERICAN SOCIETY FOR TESTING MATERIALS—Spring Meeting, Hotel Edgewater Beach, Chicago, Ill.

March 28-30
SOCIETY OF AUTOMOTIVE ENGINEERS—Transportation Meeting, Statler Hotel, Cleveland, Ohio.

than double the aircraft's rate of descent without increasing forward speed or introducing excessive structural stresses.

Two four-engine planes were used during the demonstration—a Douglas C-54 equipped with the new reversible propellers and a conventional DC-4. Descents of both planes were made from 15,000 ft. Elapsed time before contact with the ground for the DC-4 was 4 min 48 sec, while that for the C-54 was 2 min 55 sec. Eighty-two seconds of the latter time were required to reach the 1,000 ft level. This rate of descent in excess of 10,000 fpm far surpasses the rates of 3,000 to 4,000 fpm usually achieved with current models of both commercial and military aircraft.

Aviation experts who witnessed the test pointed out several advantages in the application of reversible propellers. Commercial aircraft could fly virtually their entire course at the most efficient altitude and airline service could be sped up by more rapid unstacking of planes circling above airports. Military planes would have the advantage of high speed descent when evading enemy aircraft and projectiles.

Parachute Devised For Supersonic Use

A SUPERSONIC parachute, capable of being rocketed hundreds of miles above the earth inside missiles traveling more than 1,000 miles an hour can lower delicate instruments to earth with hardly a jar.

General Electric engineers developed the new parachute after ordinary chutes were torn to shreds upon entering dense air near the earth's surface during drops from the upper atmosphere. Instead of being made of silken fabric, the new parachute resembles a giant dart with a whirling propeller or vanes attached behind the tip.

These vanes when fully opened in flight extend out about eight feet and can support instruments weighing thirty pounds after slowing down from supersonic speed to about twenty-seven miles per hour.

At the peak of the flight of the rocket, or guided missile carrying it, the new parachute is expelled by an automatic trigger. As it falls and the air becomes denser, its blades begin to revolve and gradually are forced out into a completely horizontal position. This acts to brake the fall of the parachute and the ins ruments it carries in such a manner that neither are damaged.

ASME Annual Meeting and Power Show Stress Processes

AN ESTIMATED 7,000 engineers from all parts of the United States and Canada attended the 69th Annual Meeting of the American Society of Mechanical Engineers held at the Hotel Pennsylvania, New York City during the week ending December third.

The American Rocket Society, an affiliate of the ASME, held its annual convention in conjunction with the meeting, and the American Association for the Advancement of Science co-sponsored several sessions.

New technical processes that will have an impact on engineering and industry highlighted some 70 technical sessions. These dealt with machine design, power, aviation and rocketry, rubber, plastics and textiles, railroad mechanical engineering, petroleum, material handling, gas turbine, metals techniques, fuels and processing.

Lawrence A. Appley of New York, President of the American Management Association, delivered the keynote address on the theme "Opportunity for and Responsibility to the Young Graduate Engineer." Several other sessions dealing with technical education aroused considerable interest. Noted patent attorney, H. A. Toulmin, Jr., stressed the need for a reversal of current court practices in the handling of patent litigation at the Machine Design luncheon toastmastered by G. F. Nordenholt, chief editor of PRODUCT ENGINEERING.

Several new mechanical processes that promise to speed up industry, reduce waste and simplify the human factor involved were described.

Nevin L. Bean, Ford Motor Company presented a paper on Automation. This "mechanical brain" having mechanical hands moves valve guide bushings through a series of machine operations with a delicate and accurate touch that surpasses human handling.

A new continuous process for making ice by the extrusion method, so that ice freezes "from the inside out," was discussed by Professor John R. Watt of the University of Texas. Successive layers form around a central core at the rate of 10 lb per sq ft of freezing surface per hour.

A precision-built weaving machine based on the "Sulzer" model developed in Switzerland will eventually replace the conventional loom, with great savings to the textile industry. Myron S. Curtis, Warner and Swasey Co., Cleveland, pointed out design features that include the total absence of overhead works, the weaving of two widths of cloth at the same time and the formation of selvages on both edges of each piece of cloth.

JAMES M. TODD will serve as chief executive of the American Society of Mechanical Engineers during 1949. A native of Louisiana and a consultant in mechanical and electrical engineering, he specializes in air-conditioning, power plants and the equipment of large buildings and factories. Mr. Todd has headed the New Orleans sections of both ASME and AIEE and has been active on numerous national committees. He succeeds E. G. Bailey, vice-president and chairman of the board of the Babcock and Wilcox Company.

"Cold" synthetic rubber promises to be "a real commercial threat" to natural rubber according to three representatives of the General Tire and Rubber Co., Akron.

Techniques for detecting defects in railroad materials by use of fluorescent liquid and black light were described by Ray McBrian of the Denver and Rio Grande Western Railroad. These "black magic" tests were reported as being several times faster than conventional testing methods.

The important role to be played by the gas turbine in the power field was outlined by Walker Cisler of the Detroit Edison Company. Design practices for and mechanical investigations of turbine components, especially blades and nozzles, were subjects covered by H. D. Emmert, Jr., Allis Chalmers, and Carl Schabtach, General Electric Company.

ASME engineers were represented on "America's Town Meeting of the Air" radio forum by William L. Batt, Philadelphia, former vice chairman of the War Production Board and President of SKF Industries, and Leonard

J. Fletcher of the Caterpillar Tractor Co., Peoria, Ill. They upheld the negative side of the topic: "Are Our Ideals Being Destroyed by the Machine Age?"

Concurrent with the annual meeting was the National Power Show held at Grand Central Palace. More than 400 exhibitors demonstrated the latest equipment for the production, distribution and application of power. Many items of interest to the process industries, including new varieties of valves and developments in insulating materials, featured the exhibits. Edwards Valves, Inc. showed a new valve line especially designed to cut pressure loss through elimination of sharp changes in direction of flow, reduced weight of floating parts and equalization of pressure in all parts of the valve. Jenkins Brothers introduced a valve specially designed for severe throttling service.

Introducing for the first time its compact, new fluid drive hydraulic electric motors in small sizes for general industries use, American Blower Corporation representatives said the units would soon be available in 5 and 7½ hp sizes, and next fall in other sizes ranging from 1 to 20 hp. The design represents a distinct advance over previously available ones, with the fluid-drive mechanism built over standard mounting bolt holes and the motor proper suspended at the rear.

Involute Curve Layouts

MICHAEL VASVARI
Mechanical Engineer

THE METHOD PRESENTED by Mr. Allan H. Candee in his article "Formulas for Involute Curve Layouts", PRODUCT ENGINEERING, August 1948, p 145, is undoubtedly a wonderful mathematical achievement.

I added lines O_1C, OC, PC, and PK, as shown in Fig. 1 to Mr. Candee's Fig. 2. Then I derived another set of equations for the x and y coordinates for points of the involute. I believe these new equations also offer an easy, quick and clear solution.

From Fig. 1 the following relations are obvious.

$$\text{arc } \beta = \tan \alpha - \text{inv } \alpha_P \quad (1)$$

$$R_P = b/\cos \alpha_P \quad (2)$$

$$x = R_P \cos \beta - b \quad (3)$$

$$y = \rho - R_P \sin \beta \quad (4)$$

Since these equations have a few members only, the calculation is faster, and the possibility of mistakes caused by the "table difference" being less, the resulting solutions may in some instances be more precise. Further β and α_P are always large angles, but θ is often less than 3 deg, and the trigonometric functions of small angles are not exact enough for such calculations.

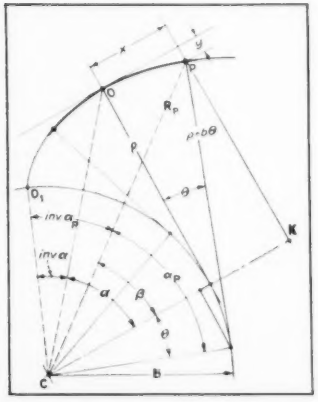


Fig. 1—Diagram for deriving equations for coordinates of points on involute.

Applying the data given by Mr. Candee, the solution with my equations is as follows:

PROBLEM: Find the x and y coordinates of point D that is θ or 12 deg away from the base circle, when

$$\rho = 9.49094,\ b = 26.07625,\ \tan \alpha = \rho/b = 0.363\ 9687$$

The angle θ does not enter my equations; they are in terms of angles α_P and β. But to follow the example given by Mr. Candee, the value of α_P corresponding to θ must be calculated.

$$\text{arc } \theta = 0.209\ 4395$$
$$\tan \alpha_P = \tan \alpha + \text{arc } \theta = 0.573\ 4082$$
$$\alpha_P, \text{ deg} = 29.830311$$
$$\beta, \text{ deg} = \alpha_P - \theta = 17.830311$$

Consequently, the problem is to find the x and y coordinates of the point on the involute curve defined by α_P.

SOLUTION:

$$\text{inv } \alpha_P = 0.052\ 7711$$
$$\text{arc } \beta = \tan \alpha - \text{inv } \alpha_P = 0.311\ 1976$$
$$\beta, \text{ deg} = 17.830311$$
$$\cos \alpha_P = 0.867\ 5024$$
$$R_P = b/\cos \alpha_P = 30.058\ 9932$$
$$\cos \beta = 0.951\ 9674$$
$$R_P \cos \beta = 28.615\ 1788$$
$$x \text{ from Eq (3)} = 2.538\ 9288$$
$$\sin \beta = 0.306\ 1989$$
$$R_P \sin \beta = 9.204\ 0319$$
$$y \text{ from Eq (4)} = 0.286\ 9119$$

These results check precisely with Mr. Candee's solution.

In precision gear cutting, involute curves of tooth profiles and cutting tools are frequently checked within an accuracy of 0.0001 in. Consequently, operational differences in calculations should not exceed 0.00005 in. For example, if ρ equals 1 in., an error in angle of one second would result in a difference of 0.000005 in. in the solution of the problem. For this reason, it is desirable to present the equations in a form that might possibly avoid such errors.

In the given example, as calculated from ρ and b there results

$$\tan \alpha = 0.3639687$$

it is reasonable to assume, however, that the cutting tool had a 20 deg pressure angle, thus making

$$\tan \alpha = \tan 20 \text{ deg} = 0.3639702$$

Since the small error in this value is within the permissible limits of accuracy, the result is not influenced. Yet it demonstrates that such errors are easily possible, and if accumulative might be magnified in a resultant value.

Since values of ρ and b are never evaluated in gear cutting practice, and since either the diameter or radius of the pitch circle is always specified, it is desirable to transform Eqs (3) and (4) into a form that is more suitable for checking involute profiles of gear teeth.

Where

r = radius of pitch circle, in.
α = pressure angle, deg

$$b = r \cos \alpha \quad (5)$$

$$\rho = r \sin \alpha \quad (6)$$

Substituting Eqs (5) and (6) in Eqs (3) and (4) results in

$$x = r\left(\frac{\cos \alpha}{\cos \alpha_P} \cos \beta - \cos \alpha\right) = r\,C_1 \quad (7)$$

$$y = r\left(\sin \alpha - \frac{\cos \alpha}{\cos \alpha_P} \sin \beta\right) = r\,C_2 \quad (8)$$

I have calculated values of the constants C_1 and C_2 very accurately for various combinations of values of α, α_P and β, and listed them in tabular form. The task of compiling these tables was greatly simplified by having at hand values of $\cos \alpha/\cos \alpha_P$, which were previously determined when making calculations for variable center distances.

"Give us the tools . . ."

What Are *YOUR* Chances If There Are No Profits?

Since the November 2 election there has been a dazzling variety of plans to have the government do more and more things and spend more and more money. But there is almost no variety in the plans which are suggested to raise the money.

"Pay for it by taxing profits," is the standard refrain. Slap on an "excess" profits tax. Boost the corporations' income tax rate.

Well – why not? Haven't the corporations been making so much money that a big chunk of it can be turned over to the government spenders without hurting anybody?

The answer is no!

How high profits should be can be debated endlessly. Some people claim that 1948 corporation profits, which will amount to about $20 billion, are too high. They emphasize the fact that profits are larger in relation to investment than they were a few years ago. Other people think profits are low. They stress the fact that profits are not much larger in relation to sales than they have been historically. Both sides agree that in some individual cases profits have been too high, as in others they have been too low or non-existent.

But if we cut the total volume of profits drastically, we shall do so at our national peril.

There is no room for debate about that. For we shall choke off the crucially important job of building new plants and equipment for our industries. Squeeze hard enough, and America will go the way of Britain – down the long and painful skids of industrial decline. Widespread unemployment, especially among our industrial workers who produce new plants and equipment, will mark the dreary way. Here is a fact which the President, the Congress, the C.I.O., and all of us have a real reason to remember:

Almost two-thirds of all profits today are going to rebuild and improve plants and equipment.

More than $13 billion of this year's profits are being plowed back. They are going – as a large proportion of profits have always gone – to buy for workers better tools to work with, better surroundings in which to work. They are making possible better products, and more of them, for all of us.

The figures below show how companies have put more and more profit-dollars and a larger share of their profits to work in the business:

YEAR	PROFITS REINVESTED	% OF TOTAL PROFITS
1929	$2.6 billion	31%
1939	1.2 "	24%
1943	5.9 "	57%
1944	5.2 "	53%
1945	4.2 "	47%
1946	6.9 "	55%
1947	11.2 "	62%
1948 est.	13.0 "	65%

continued on next page

The record shows that each of us is the real beneficiary of this plowing back of profits.

Every American has benefited from these profits. Each dollar that business has put into its plants and equipment in the last thirty years has increased our yearly production by 35 cents.

This re-investment of profits has helped make possible a 75% increase in living standards since 1919.

It has helped increase wages from an average 48 cents an hour in 1919 to $1.36 today. Allowing for higher prices, that increase means that an hour's work today will buy twice as much as it did thirty years ago.

Why must business retain these billions of profits to improve its plants and equipment? Why must it plow back more and more? *The reason is that business already is caught in a tax squeeze.*

Federal taxes alone take at least thirty-eight of each one hundred dollars a company earns. Then, if the company pays out to its stockholders any part of what is left as dividends, the federal personal income taxes of the stockholders may take up to 77% of those dividends. Under these conditions, so few people are willing to invest in industry that the stock market is stagnant. Companies can not raise in that market the money they need for improvements.

The result: business must rely more and more on plowed-back profits to pay for new plants and equipment.

We know that everywhere in industry new and better ways of producing goods are standing ready for use. The previous editorial in this series mentioned some of them. We know, too, that depression and war put our industries far behind schedule – as much as $100 billion behind – in getting the new tools they should have had to keep themselves in first-class shape. McGraw-Hill is now completing a survey of industry that will measure these needs. The results will be published in this editorial series. We know already that in 1949 alone industry will need $18 billion or more for this purpose.

And all but a small fraction of that sum must come from profits.

Our prosperity, our strength as a nation, our hopes for better living depend on our continuing to generate and to plow back a large volume of profits.

For that reason we should not thoughtlessly follow these people who propose to pay for any and all new government activities by saying simply, "Soak the corporations." There is no need to follow them. There are other ways of obtaining necessary funds.

First and foremost should be economy within the government itself. If its citizens must pay still higher taxes, then surely government should exercise rigid self-restraint, cutting out all but the most essential activities and expenses.

After economy should come consideration of a broader federal tax base.

If these and other methods of raising money are inadequate and if taxes must take a bigger bite from business profits, two facts are clear. We should not adopt an "excess" profits tax with all of its complications and all of its corrupting effect on business. A moderate increase in the regular income tax on corporations is much less dangerous. *But even such an increase, if necessary, should be accompanied by special allowances for expansion and depreciation that will encourage companies to continue spending their earnings for new plant and equipment.* We all have a stake in that.

At this critical juncture in our history profits have a new and vastly more important role than they have ever had. In unprecedented degree they are the drive behind our present prosperity and the key to a better, stronger future.

Give profits the axe and the blow does not stop there.

It cuts into the employment, the prosperity and the strength of our nation.

Everyone of us has a stake in how the President and Congress handle taxes on profits – and now is the time to remind them of that stake.

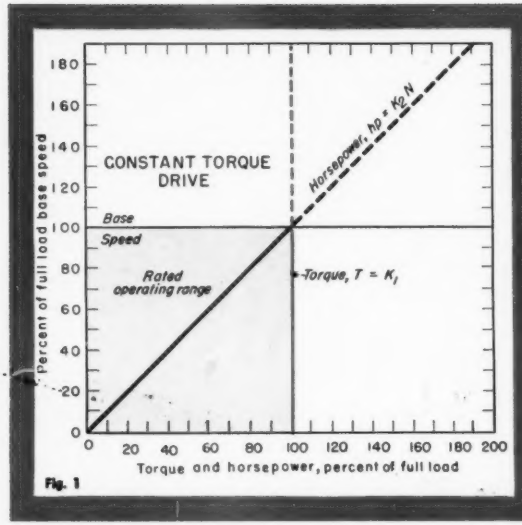
President, McGraw-Hill Publishing Company, Inc.

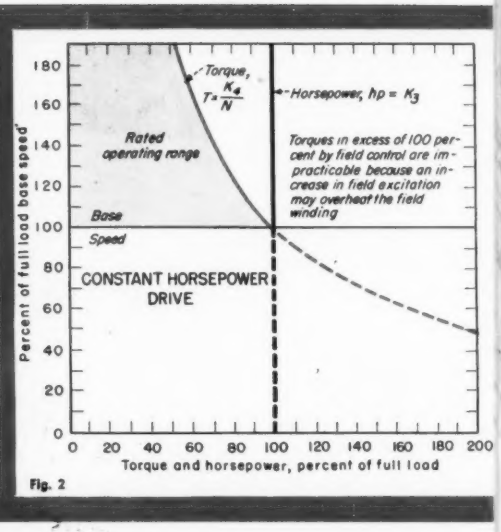
SPEED CONTROL FOR ELECTRICAL DRIVES

PERFORMANCE CHARACTERISTICS • EQUIPMENT REQUIREMENTS • CIRCUIT DIAGRAMS

By **R. B. IMMEL**, *Design Engineer, Westinghouse Electric Corporation*

Operating characteristics of types of electrical drives. Twenty-one methods of electrical speed control analyzed and graphically compared against each other. Speed range, speed change, horsepower and other performance factors. Torque-speed-horsepower curves for the different speed control systems. Aspects of the driven load that affect the choice of the type of control.


CONSTANT TORQUE DRIVE
Horsepower, hp = K2 N
Base Speed
Rated operating range
Torque, T = K1
Percent of full load base speed
Torque and horsepower, percent of full load
Fig. 1


Torque, T = K4/N
Horsepower, hp = K3
Rated operating range
Torques in excess of 100 percent by field control are impracticable because an increase in field excitation may overheat the field winding
Base Speed
CONSTANT HORSEPOWER DRIVE
Percent of full load base speed
Torque and horsepower, percent of full load
Fig. 2

Speed Control for Electrical Drives

R. B. IMMEL
Design Engineer,
Westinghouse Electric Corporation

SUCCESSFUL OPERATION of many motor driven machines or devices depends entirely upon the speed control.

Some machines require operation over a wide range of speed; others need a closely regulated speed. With electrical speed control, relatively small changes in voltage and current easily effect large changes in speed, torque, or horsepower of the drive motor. Generally, electrical speed control is more flexible, quicker and easier to adjust, faster in response, and more suitable for complicated sequence operations and interlocking than other speed control methods. It is well adapted to automatic speed control and often provides a wider speed range than is otherwise possible.

Selection of the proper control for a specific application is just as important as selection of the most suitable motor. In choosing a coordinated electrical drive many factors must be considered. These include the type of power supply available, type of machinery to be driven, speed range desired, type of control wanted, location of the electrical equipment, the duty cycle, operating personnel available, and cost.

Usually the first consideration in selecting an electrical drive comprising motor, control, and auxiliary control units is the available power supply. But, in many applications the speed control factor is more important than the power supply factor in selecting the electrical drive that, in the long run, is the most economical and satisfactory.

Complete knowledge of the essential features of the driven machinery and the load characteristics is necessary for intelligent decisions. Except for a-c synchronous motor drives or drives with speed regulating controls, the speed of many electrical drives is determined directly by the torque requirements of the load. When the speed-torque requirements of a driven load are definitely known, the electrical drive performance can be predicted with reasonable accuracy. Where: T=torque, lb-ft; N=speed, rpm; K=5,250, a conversion constant; and hp=horsepower, then T=hp x K/N or hp=T x N/K.

Electrical drives can be classified by the load requirements as: (1) constant torque, (2) constant horsepower, (3) combination of constant torque and constant horsepower and (4) variable torque.

Types of Electrical Drives

Constant Torque. Compressors, chain grate stokers, belt conveyors, cranes and hoists, plunger pumps, and loading machines are typical constant torque loads. Total pull at any time is constant and independent of the speed as shown in Fig. 1. Horsepower varies directly as speed. Friction represents a constant torque load. In certain inefficient machines the predominating friction load causes the machine to have a constant torque characteristic regardless of the useful load characteristic.

Constant Horsepower. Machine tools, lathes, planers, drill presses, and any machine with a controlled load are typical constant horsepower loads as shown in Fig. 2. With a light load the machine can be operated relatively fast; for a heavy load, the machine should be operated slower. For example, as the cutting speed of a lathe is increased, the depth of cut is decreased to reduce the torque required for driving the load. Both the horsepower required and volume of metal removed per unit time is

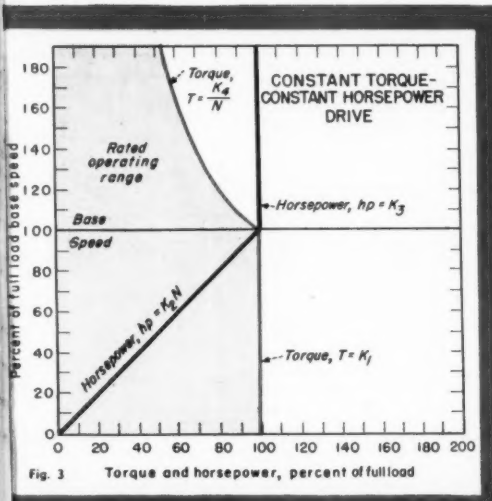

CONSTANT TORQUE-CONSTANT HORSEPOWER DRIVE
Torque, $T = \frac{K_4}{N}$
Rated operating range
Base Speed
Horsepower, $hp = K_3$
Horsepower, $hp = K_2 N$
Torque, $T = K_1$
Percent of full load base speed
0 20 40 60 80 100 120 140 160 180 200

Fig. 3 Torque and horsepower, percent of full load

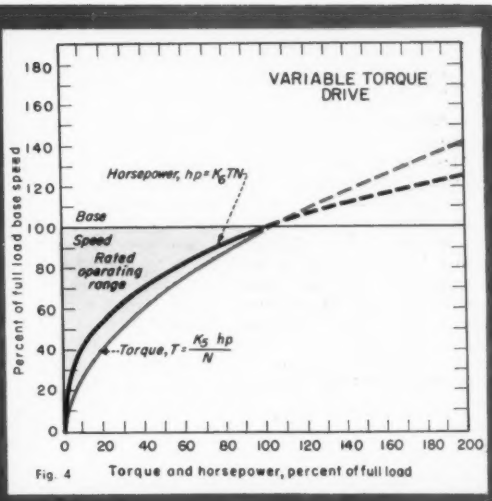

VARIABLE TORQUE DRIVE
Horsepower, $hp = K_6 TN$
Base Speed
Rated operating range
Torque, $T = \frac{K_5\ hp}{N}$
Percent of full load base speed
0 20 40 60 80 100 120 140 160 180 200

Fig. 4 Torque and horsepower, percent of full load

approximately constant over the entire speed range.

Similarly, constant horsepower is required for a core type paper winding machine. As the roll gets bigger, the driving motor must slow down to hold the sheet tension and linear paper speed constant.

Constant Torque-Constant Horsepower. Loads requiring a wide speed range often use a combination constant torque and constant horsepower drive, as shown in Fig. 3. This drive characteristic is typical of a d-c shunt motor that uses armature voltage control below the base speed for constant torque and field control above the base speed for constant horsepower characteristics. Typical applications include elevators and metal working planers.

Variable Torque. Fans, blowers, and centrifugal pumps are typical variable torque loads since torque varies directly with speed as shown in Fig. 4. Usually, horsepower is considered to vary approximately as the square of the speed for a variable torque load.

In Figs. 1 to 4, different conversion constants, K, for the curves are shown by subscripts, as the numerical value for K is not the same for the various curves.

Match Motor To Load

The characteristics shown in Figs. 1 to 4 are the safe maximum or boundary conditions for the driving motor. Seldom will the speed-torque characteristics of a single load exactly match those of the drive motor and control. But for a continuous duty rating, the load speed-torque requirements should never exceed those of the drive motor. Torque and horsepower output of the motor are related directly to the current that the motor draws from the power supply. Therefore, the maximum torque or horsepower limitations must not be exceeded or the motor will overheat. Because a motor generally has considerable thermal capacity, intermittent overloads are usually not harmful. Applications such as cranes and hoists usually use intermittently rated motors for economy.

At every speed, the available motor torque must be equal to or exceed that required by the load. The maximum torque and speed of the load usually determines the horsepower rating of the motor. This horsepower rating is many times that when the machine is operated at less than maximum speed.

Except where constant speed is maintained, such as by synchronous motors or automatic speed regulators, the speed is determined by the driven load. The motor always operates at a speed where its speed-torque characteristics are in equilibrium with the speed-torque requirements of the load. This condition is illustrated on many of the curves used later in this article where the operating speeds are predicted graphically by plotting both the load and drive motor characteristics on the same set of coordinates.

Based on a general system of classification built on their inherent speed characteristics, motors are classified by NEMA as:

Constant-Speed: When speed of motor during normal operation is constant or practically constant. For example, a synchronous motor, an induction motor with small slip, or an ordinary direct-current shunt-wound motor.

Varying-Speed: When the speed of the motor varies with the load. Ordinarily the speed decreases when the load increases, such as for a series motor or an induction motor with large slip.

Adjustable-Speed: Motor speed can be adjusted gradually over a considerable range and when once adjusted, the speed is practically unaffected by changes in load. A shunt-motor designed for a considerable range of speed adjustment by field-resistance control is a typical motor of this type.

Adjustable Varying-Speed: Motor speed can be adjusted gradually, but when once adjusted for a given load the speed changes appreciably with change in load. A compound-wound d-c motor with speed adjusted by field control, or a slip-ring induction motor with rheostatic speed control are typical motors of this class.

Multi-Speed: Motor can be operated at any one of two or more definite speeds, each being practically unaffected by the load. A d-c motor with two armature windings, or an induction motor with windings that can be grouped for different pole combinations are typical.

Speed Control Methods Compared

Basic methods of motor speed control, including starting, are compared in the rest of this article. Speed range, speed regulation, size of drive, and economics are stressed. A clear concept of these relationships in basic control schemes makes it easy to understand extremely complicated systems that are outside the scope of this article. The systems discussed can generally be manually or magnetically operated. Generally, a manually operated speed control is simpler and less expensive than magnetically operated control. Usually, magnetic control is necessary for satisfactory automatic operation, overload protection, interlocking, and limit or auxiliary switch control as will be brought out in later discussion.

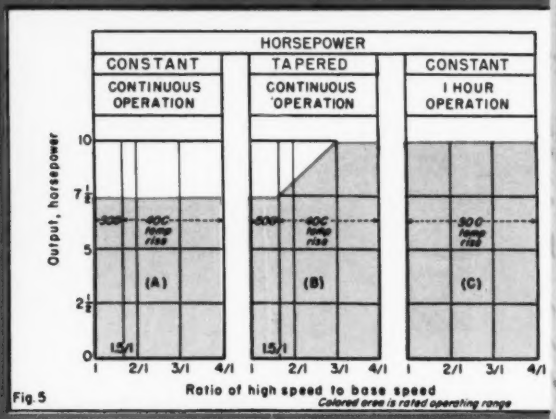


Fig. 5

D-C Motor Drives— D-C Power Source

There are many applications where the use of d-c drive motors is absolutely necessary to meet the operating requirements. In general, an adjustable and wide speed range with precise speed control can be obtained only with d-c drives.

D-C Shunt Wound Motor Drives

At constant armature voltage and fixed field current, constant speed shunt motors operate at practically constant speed regardless of the variations in the load. In general, as the load varies from no-load to full-load, the change in motor speed is less than 12 percent for motors from 1 to 5 hp, and 10 percent for larger motors. For adjustable speed motors, regulation does not exceed 22 percent for 1 to 5 hp motors and 15 percent for larger motors.

Usually, constant speed shunt wound d-c motors are suitable over a speed range up to 2 to 1 by field control and for constant horsepower output, provided the top speed does not exceed the maximum safe rpm for the motor.

Shunt wound d-c motors with a speed range by field control of 3 to 1 or more are classed as adjustable speed motors. Standard 3 to 1 and 4 to 1 speed range motors can be applied when the top speed does not exceed the motor safe mechanical speed. Special motors with speed ranges up to 6 to 1 and 8 to 1 are available; but they cost more because of special field windings and frames.

A standard adjustable speed shunt wound d-c motor are rated three ways:

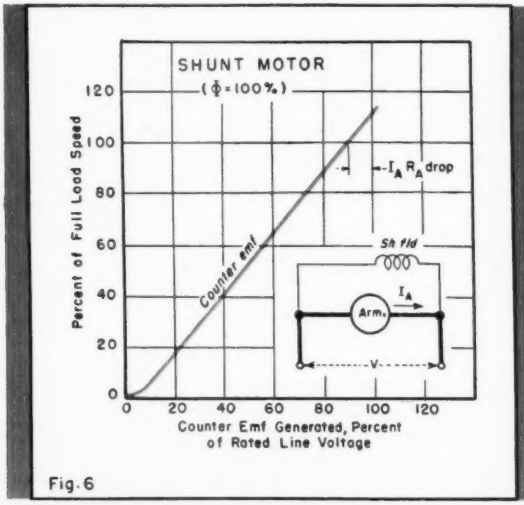


Fig. 6

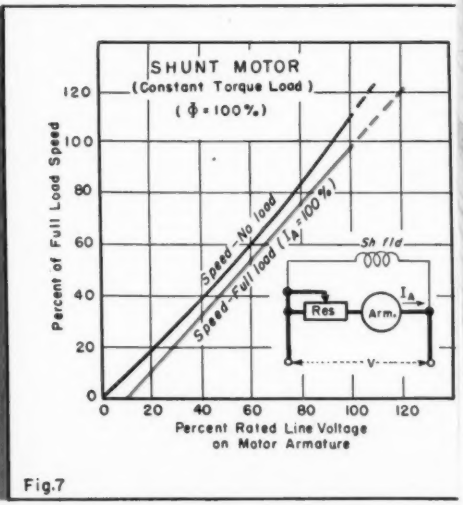


Fig. 7

Constant Horsepower, Continuous Operation, 40 C Rise. An adjustable speed shunt wound d-c motor has a 40 C temperature rise when continuously operated at constant horsepower output. It will develop the rated horsepower from 150 percent of the minimum or base speed to the maximum speed. From minimum speed to 150 percent of minimum speed, the motor can develop its rated horsepower; however, its temperature rise may be as high as 50 C. Usually 50 C is considered to be within safe limits.

Tapered Horsepower, Continuous Operation, 40 C Rise. The same motor can have also a tapered horsepower rating. Because ventilation is much better at high than low speeds, a motor will develop the next higher hp rating at the higher speeds and still not exceed a 40 C rise. The motor can be operated continuously and it will develop the maximum horsepower at three times the base speed. The horsepower decreases in direct proportion to the decrease in speed, down to the specified horsepower rating at 150 percent of the base speed. For motors with a speed range of 4 to 1, the maximum rated horsepower is considered constant from three times the minimum speed to four times the minimum.

Constant Horsepower, 1 Hour Operation, 50 C Rise. The same motor with a 1 hr rating will develop the next higher rating over the entire speed range with a 50 C rise.

These three ways of rating a given motor make it possible to apply an adjustable speed motor to a given application in the most economical manner. For instance, Fig. 5 compares these ratings for a 7½ hp motor for continuous operation with a 40 C rise.

Even though a continuously rated motor for constant or tapered horsepower output is classified as having a 40 C temperature rise, it will usually have a 50 C rise from the base speed to 1.5 times the base speed because of reduced ventilation at lower speeds. On most adjustable speed applications, the motor is generally operated above 150 percent of the base speed. This is an economical method of rating a motor. A larger frame size is required for a motor that develops the rated horsepower from base to maximum speed without exceeding 40 C rise at the lower speeds.

D-C Motor Basic Characteristics and Speed Formulas

The counter emf generated by a motor opposes the line voltage. It is almost directly proportional to the motor speed. Where: E_A = counter emf; K = motor constant; ϕ = field flux; and N equals speed, then $E_A = K \phi N$. This inherent motor characteristic is shown graphically in Fig. 6.

Also, where: I_A = armature current; V = line voltage; R_A = total armature circuit resistance, then

$$I_A = \frac{V - E_A}{R_A} \text{ or } V = E_A + I_A R_A$$

From the above two formulas the basic speed equation for a d-c motor can be derived as

$$N = \frac{V - I_A R_A}{K\phi}$$

Since the product of the full load armature current I_A and the armature resistance R_A can be considered a constant, with constant field strength ϕ the motor speed can be adjusted by changing the line voltage, as shown in Fig. 7. Also, the equation shows that the $I_A R_A$ voltage drop must be relatively small in comparison to the impressed line voltage if the speed is to remain practically constant with changes in the armature current I_A. Generally, for shunt wound motors, this value $I_A R_A$ is approximately 10 percent of the line voltage.

Speed also can be changed by varying the shunt field strength. As shown in Fig. 8, with constant line voltage V the speed increases as the field becomes weaker. To obtain speeds below the base or full field speed, the voltage applied to the motor armature must be reduced.

D-C Motor Basic Torque Characteristic and Formula

Torque T developed by a d-c shunt motor is proportional to the product of the field flux and the armature current I_A. Thus $T = K \phi I_A$. During starting and accelerating, most adjustable speed motor controllers provide full shunt field strength. This helps the motor to develop the required torque with minimum armature current. For constant field excitation, torque is almost directly proportional to the armature current as shown by Fig. 9. Motor torque can be controlled by changing the voltage applied to the armature, or by limiting the armature current by a series resistor.

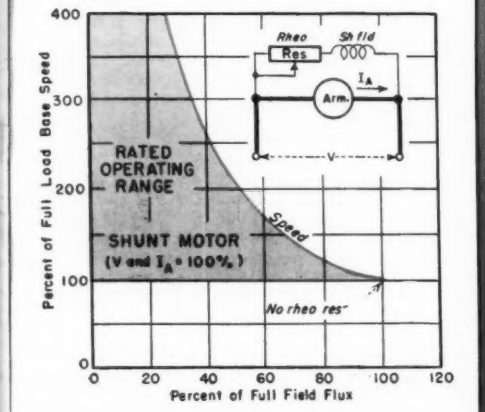


Fig. 8

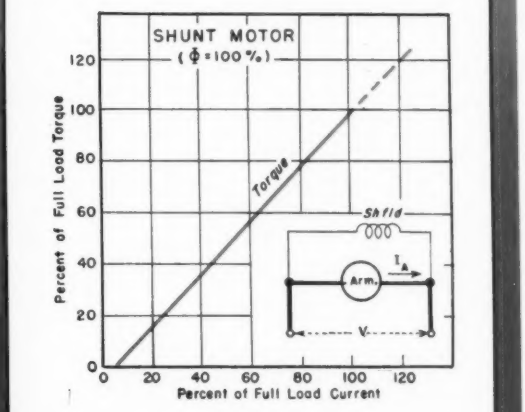


Fig. 9

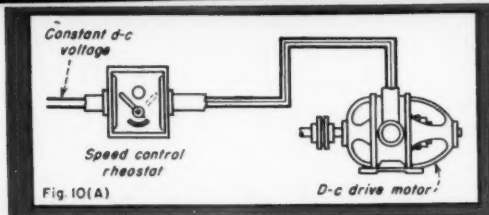


Fig. 10(A)

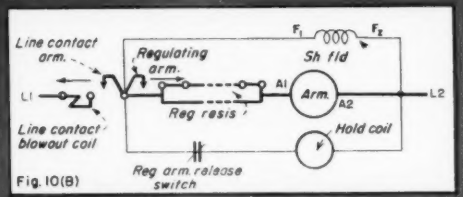


Fig. 10(B)

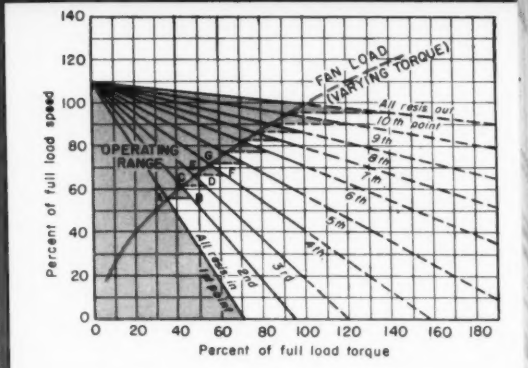


Fig. 10(C)

Speed Adjustment By Armature Resistance Control

Characteristics: Speed range, 2 to 1 with 50 percent speed reduction by armature resistance control; speed change, speed decrease from no load to full load approximately 50 percent at low speed and 10 percent at base speed; horsepower, $\frac{1}{3}$ to 50.

The simplest and lowest cost d-c adjustable speed drive is shown in Fig. 10. Different values of resistance are inserted in the armature circuit by the manual controller.

Moving the control rheostat handle counter clockwise closes the line contacts. This starts and accelerates the motor to approximately 50 percent of full load speed, if the load is correct for the resistors. As shown in the circuit diagram, a magnet holds the line contact arm closed. Then the speed regulating arm can be moved clockwise to short out the resistor and increase the speed. A star wheel and roller positively positions the regulating arm contacts on the stationary contact segments. Moving the regulating arm to the "Off" position opens the release switch just after the arm moves past the lowest speed point, which releases the line contact arm and opens the main circuit, stopping the motor. Since the line contact arm is held closed magnetically, this controller provides low-voltage protection and insures that the motor is started with all the resistance in the circuit. This type of controller does not usually have overload protection.

For armature resistance control, usually the motor operates with full shunt field strength. Typical speed-torque curves for a 10 point controller with a class No. 93 NEMA resistor for varying torque applications are shown. This resistor class provides 50 percent speed reduction with at least 35 percent of full load torque on the first point. Regulation is poor, varying from about 120 percent at low speed to about 10 percent at the rated full-load speed. Additional intermediate speeds can be obtained by using more resistor steps. NEMA class No. 95 resistors are used for constant torque applications that provide 50 percent speed reduction with not less than 80 percent of full load torque.

A superimposed speed—torque characteristic of a fan load is shown on Fig. 10 (C). When the line contact is closed, the motor will be accelerated on the first point to a speed indicated by *A*. When the regulating arm is moved to the second point, the motor will then increase in speed from point *A* to point *B* ultimately to point *C*, and so on.

For speed reductions below 50 percent of the rated speed, the armature can be shunted by a resistor. This greatly improves the regulation and reduces the differential between the no-load and full-load speeds as shown in Fig. 11. When the percent of the impressed voltage value on the armature is known, the percent of base speed can be found for both no and full loads from Fig. 7. Although an armature shunting resistor gives good speed control at low speeds, it is not efficient since energy is dissipated in the resistors. Curves in Fig. 11 are for the same full load speed for either method of control.

Speed Adjustment By Field Excitation Control

Characteristics: Speed range, 4 to 1 speed increase by field control; speed change, speed decrease from no load to full load approximately 10 percent at base speed and 25 percent at high speed; horsepower, unlimited.

The system for a typical drive for speed adjustment of a d-c shunt motor by field control is shown in Fig. 12. In general, magnetically operated starters are used because of ease for remote operation, interlocking, and overload protection. Pushing the start button causes time delay accelerating contactor main contact $1A$ to open, thus inserting the first step of the starting resistor in the circuit. Also, auxiliary contact $1A_a$ closes energizing the second accelerating contact coil $2A$. Main contacts $2A$ open; auxiliary contact $2A_a$ close and energize line contactor coil M, which closes line contacts M. Thus, the motor starts with reduced voltage on the armature and full voltage on the field.

Also, the line contactor auxiliary contact M_a opens and de-energizes coil $1A$ to initiate the time delay period. After several seconds, main contacts $1A$ close and short out step $R1$-$R2$ of the starting resistor. Auxiliary contacts $1A_a$ open and de-energize coil $2A$ of the second inductive time delay accelerating contactor. After another period of a few seconds, main contacts $2A$ close and short-out step $R2$-$R3$. With the starting resistor completely shorted-out, full voltage is applied to the motor armature. The motor continues to run until stopped by the stop pushbutton, overload relay, or a power failure.

The field accelerating relay FA is operated by both a series and a shunt wound coil. The shunt wound coil is connected in parallel with the starting resistor and insures that the field rheostat is always shorted out by contacts FA during starting. Before the motor armature starts to rotate, approximately full line voltage is across the starting resistor and shunt coil FA. After the accelerating period, contact $2A$ shorts out the shunt coil FA.

After the motor reaches a speed corresponding to the speed for full line voltage impressed on the motor armature, contact FA opens and speed can be controlled by the field rheostat.

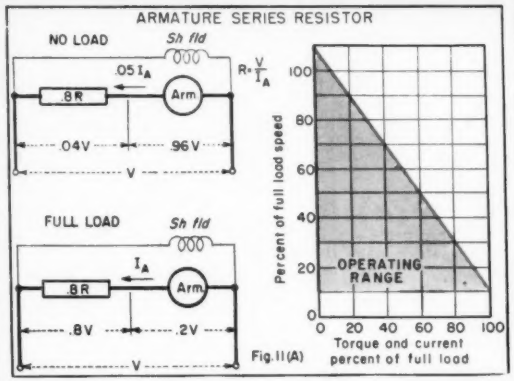


Fig. 11(A)

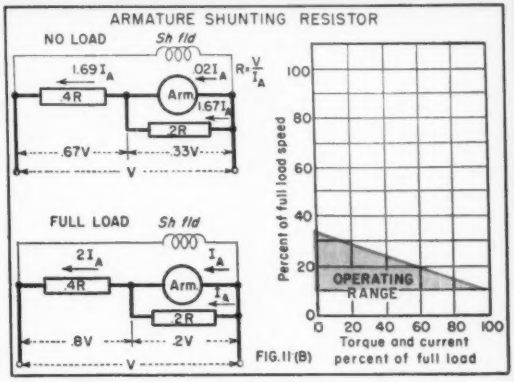


FIG. 11(B)

As long as the starting current is above a predetermined value, series coil *FA* holds contacts *FA* closed even though the shunt coil is ineffective. Also, the series coil automatically applies full excitation to the shunt field if current increases beyond preset value.

Speed—torque characteristics of a d-c drive motor with a thirteen point field rheostat are shown on Fig. 12; intermediate speeds can be obtained by using a rheostat with smaller resistance steps. Regulation is best at the base speed and increases as the speed increases. Since this drive has a constant horsepower characteristic, the safe drive torque available decreases as the speed increases, as shown. For motors with a tapered or 1 hr hp rating, max. torque is greater.

Speed Adjustment By Special Field Excitation Control

Characteristics: speed range, 8 to 1 speed increase by field control; speed change, speed decrease from no load to full load approximately 15 percent at both base and high speed; horsepower, 1 to 40 (40 C continuous), 1—1½ to 40—50 (40 C continuous operation, tapered horsepower), 1½ to 50 (50 C 1 hr operation.)

By using a d-c motor with a double field stator and a two circuit armature as shown in Fig. 13, 8 to 1 speed range can be obtained by field excitation control. This construction and mode of operation minimizes the factors that limit the speed range of standard d-c shunt motors such as: changes in residual magnetism, field distortion, demagnetization of the main field by the armature, and an increase in the reactance voltage.

Essentially, the 8 to 1 motor maintains a substantial value of field flux, even at high speeds. (See PRODUCT ENGINEERING, Aug. 1947, p 166) The two-circuit armature winding means that between brushes of opposite polarity there are only two circuits. The voltages generated in the coil sides under each of the four poles add algebraically between the brushes of opposite polarity. Coils on the two main poles form one field winding and the coils on the two lower adjustable field poles form a second field winding. The main field winding substantially provides a strong constant magnetic field. The flux of the adjustable field is changed from full field cumulative to the necessary differential value. Higher efficiencies and better regulation are secured by varying the main field flux down to 60 percent of normal full field. The main field is placed at the top of the frame so the upward magnetic attraction will reduce the thrust of the armature on the bearings.

As shown, the rheostats are connected mechanically to automatically insure optimum field conditions. In the circuit diagram, the magnetic timestarter operates similarly to the controller described for the circuit in Fig. 12. When the field accelerating relay *FA* operates, the adjustable shunt field automatically supplies a maximum

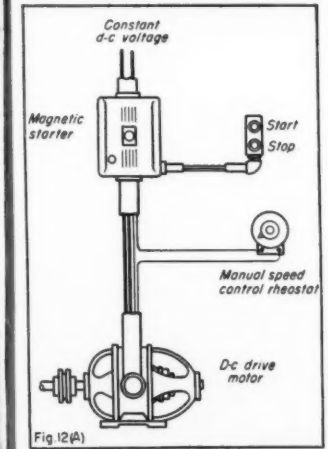


Fig. 12(A)

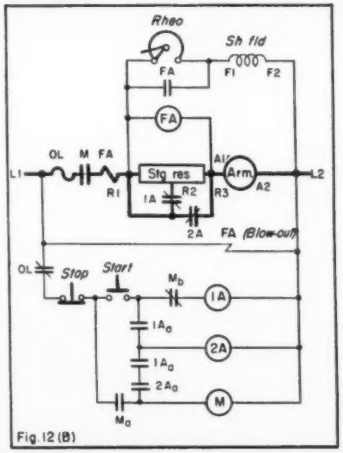


Fig. 12(B)

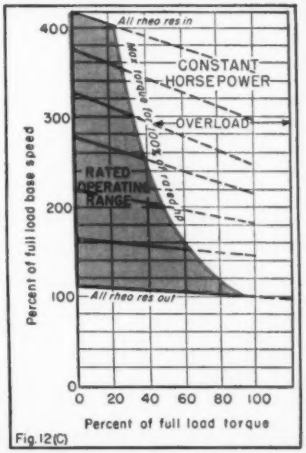


Fig. 12(C)

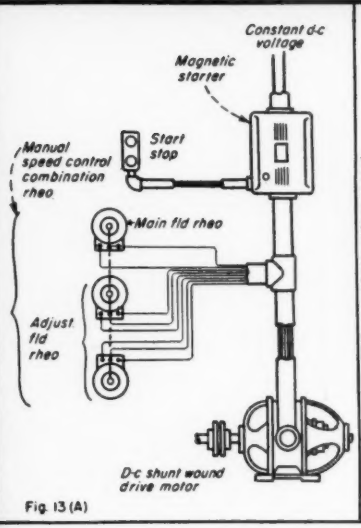


Fig. 13 (A)

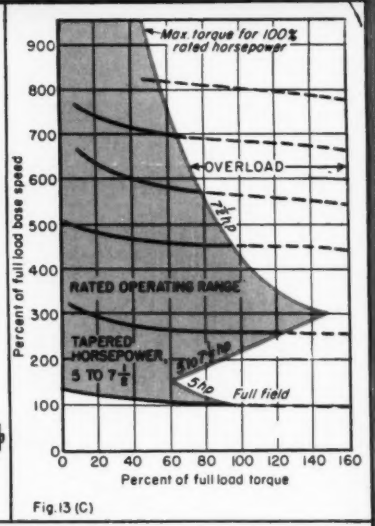

Max torque for 100% rated horsepower
OVERLOAD
RATED OPERATING RANGE
TAPERED HORSEPOWER, 5 TO 7½
Full field
Percent of full load base speed
Percent of full load torque

Fig. 13 (C)

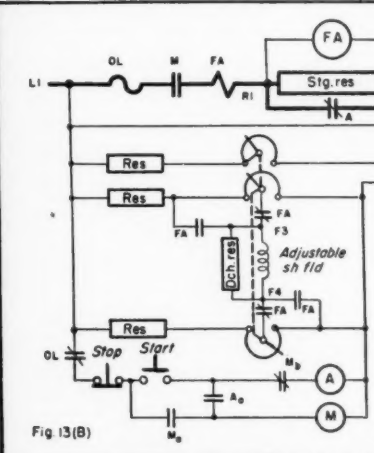


Fig. 13 (B)

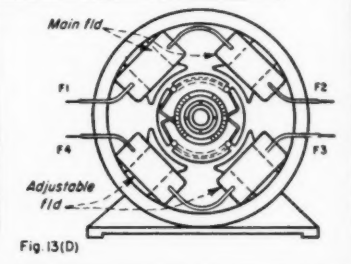


Fig. 13 (D)

value of field flux that adds to the main field. This permits the motor to produce substantial torque with relatively low armature current.

The typical speed-torque curves for a 5-7½ tapered horsepower rated motor with a 450 rpm base speed show good regulation over the entire speed range. This motor has a 5 hp continuous operation rating with a 50 C rise from 1 to 1½ times base speed. From 1½ to 3 times the base speed the horsepower tapers from 5 to 7½ hp for continuous operation with 40 C rise. The motor develops a constant 7½ hp from 3 to 8 times base speed with 40 C rise. The safe maximum torque for the motor without overloading is shown. This adjustable speed drive is well suited for applications such as machine tools. Generally, it reduces the gearing and improves flexibility by providing practically a stepless speed range.

Speed Adjustment by Combined Armature Resistance and Field Excitation Control

Characteristics: Speed range, 8 to 1 with 50 percent reduction by armature resistance control and 4 to 1 speed increase by field control; speed change, speed decrease from no load to full-load approximately 50 percent at low speed, about 10 percent at base speed and 25 percent at high speed; horsepower, ¼ to 50.

The speed range of a d-c shunt motor drive can be greatly increased by using both armature resistance and field control means, Fig. 14. A drum controller functions like the face-plate rheostat previously described. But it is more sturdy and is made in higher

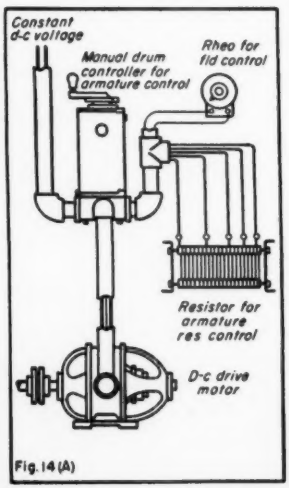

Constant d-c voltage
Manual drum controller for armature control
Rheo for fld control
Resistor for armature res control
D-c drive motor

Fig. 14 (A)

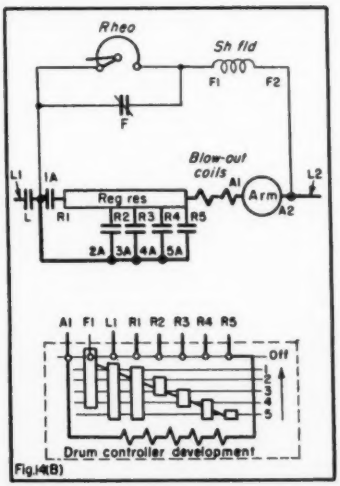


Fig. 14 (B)

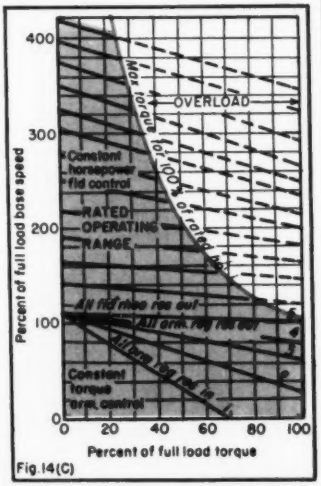


Fig. 14 (C)

ratings. In general a drum type controller costs less than a magnetic controller. It does not have the inherent ease of operation, remote or automatic operation, or interlocking features of magnetic controllers.

In the typical diagram shown for a five point drum controller, the *F* contact on the drum opens only on the fifth point. Thus, the shunt field is fully excited when the motor is operated with reduced voltage on the armature. When all of the regulating resistor is shorted out, the field rheostat can be used to adjust the speed for operation above the base speed.

This type of d-c drive falls in the constant torque and constant horsepower classification. The speed—torque curves show a drive with five points of armature resistance control and a typical number of field control points. Intermediate speeds can be obtained by using more points or steps. Speed regulation is best at the base speed and poorest for lower speeds.

D-C Compound Wound Motor Drives

Compound wound d-c motors have both shunt and series field windings. The relative strength of the two fields determines to what extent the motor operation approaches the shunt or series motor characteristics. In general, the formulas previously given for the counter emf, speed, and torque of a d-c shunt motor apply to a compound wound motor. A compound wound motor has a relatively high starting torque that approaches that of a series motor and yet has the safe no-load speed of a shunt wound motor.

From no load to full load, the drop in speed or regulation of a compound wound motor is approximately 25 percent for operation at full shunt field excitation.

Compound wound motors are used extensively where a reasonably constant speed is required and where a high starting torque is required to accelerate the driven machine.

In general, compound wound motors are not recommended for adjustable speed applications. This is because weakening the shunt field to obtain a speed increase changes the proportionate effect of the shunt and series fields. Also, the speed characteristics of a motor operated with less than full shunt field strength is similar to that of a series wound motor with the series field shunted.

The series field can be connected to be cumulative or differential with respect to the shunt field.

Compound wound motors have a speed-torque characteristic that is suitable for machines with flywheels or with a high inertia load characteristic. When load is suddenly applied, the drooping speed trait of the motor lets the flywheel give up its kinetic energy. Thus, motor size, disturbances on the power supply, and motor heating are all reduced.

D-C Series Wound Motor Drives

The d-c series wound motors are inherently varying speed motors since the field winding is in series with the armature. Any change in the armature current changes the field flux. Relatively, a series motor provides an extremely high starting torque with relatively low starting current. Series motors can start and accelerate heavy loads with less current than other types.

On light or no loads, the motor speed may be dangerously high. As the series field flux decreases, the armature current decreases, and the armature speeds up to generate the required back emf. For this reason, series motors should be used only where the load is never entirely removed from the motor or where close supervision is maintained. A series motor should not be connected by a belt to the load; it should always be connected by gears, chains, couplings, or other positive means.

Series wound motors are applied mainly for widely varying loads, such as are typical for hoists, cranes and winches. Sometimes series motors have a shunt that supplies just enough field to avoid excessive speed on light loads.

While the general counter emf, speed, and torque equations given for d-c shunt motors apply to series wound motors, the only practical way to control the speed is to change the voltage applied to the armature and series field. Any attempt to control the series field excitation separately voids the basic reason for using a series motor.

Speed Adjustment By Armature Resistance Control

Characteristics: speed range, depends entirely upon the load; speed change, speed decrease from no load to full load approximately 100 percent or more at both low speed and base speed; horsepower, 1 to 200, intermittent. Often series motors are controlled by manually operated drum controllers, as shown in Fig. 15. Where ease of operation and higher

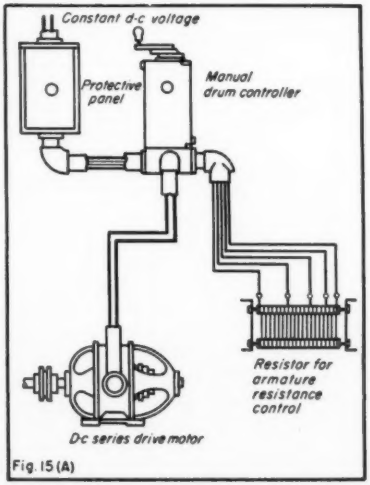


Fig. 15 (A)

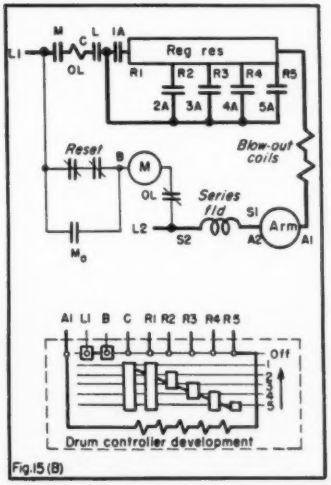


Fig. 15 (B)

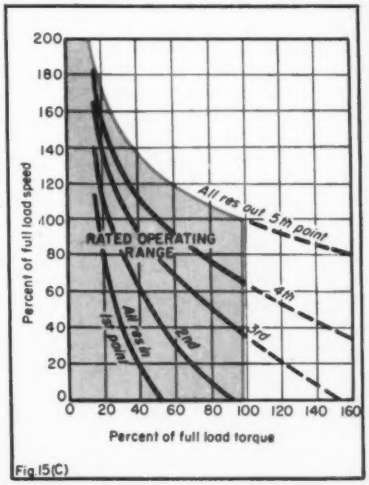


Fig. 15 (C)

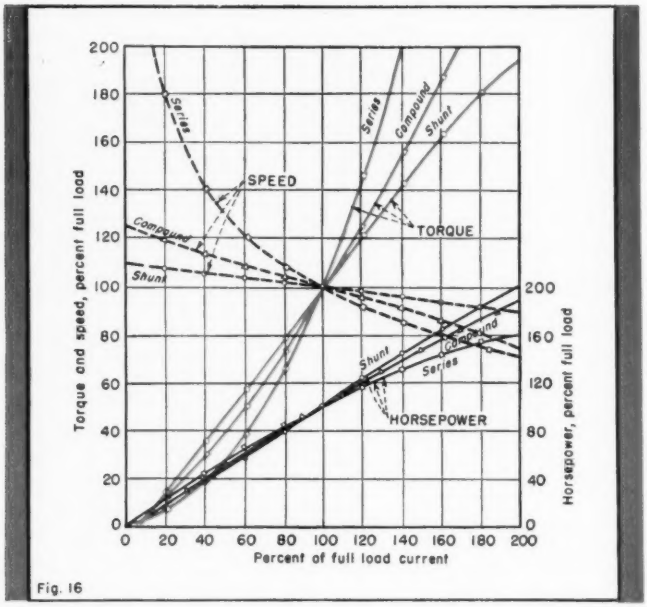


Fig. 16

first cost of the controller is justified, automatic magnetic control operated from a master switch or pushbutton station is used. For applications such as on large crane or steel mill drives the motor currents are so large that only magnetically operated controllers are satisfactory.

As shown in the typical circuit diagram, a protective panel with a line contactor *M* and an overload relay *OL* are used to provide overload and low voltage protection. The line contactor coil *M* is energized initially only in the drum "Off" position through the "Reset" contact. When the drum is moved to any other position, the coil remains energized through its auxiliary contact M_a. If voltage fails or the overload relay operates, the coil *M* is de-energized and the contactor opens the line contacts *M* and stops the motor. The motor can be restarted only by moving the drum controller to the "Off" position. The protective panel prevents starting the motor unless all the starting and regulating resistance is in the circuit.

The typical speed-torque curves show clearly the dangerous speed characteristic of a series motor with light load.

Comparison of Typical D-C Motor Characteristics

The speed, torque, and horsepower characteristics vs. current for typical shunt, compound, and series wound motors operated at their base speeds are compared in Fig. 16. For clarity, the horsepower and torque curves are plotted to a different ordinate scale. For torques in excess of 100 percent of full load torque, the series motor develops more torque per ampere than either the shunt or compound motors.

Graphical Analysis for Shunt Wound Motor Drive

In selecting the proper drive such factors as speed range, size, cost and regulation, must be considered. How to analyze a typical application where it is desired to apply a d-c shunt wound motor to a constant torque load which requires speed adjustment from 450 to 1,800 rpm is shown in Fig. 17.

The speed-torque and speed-horsepower requirements of the load are

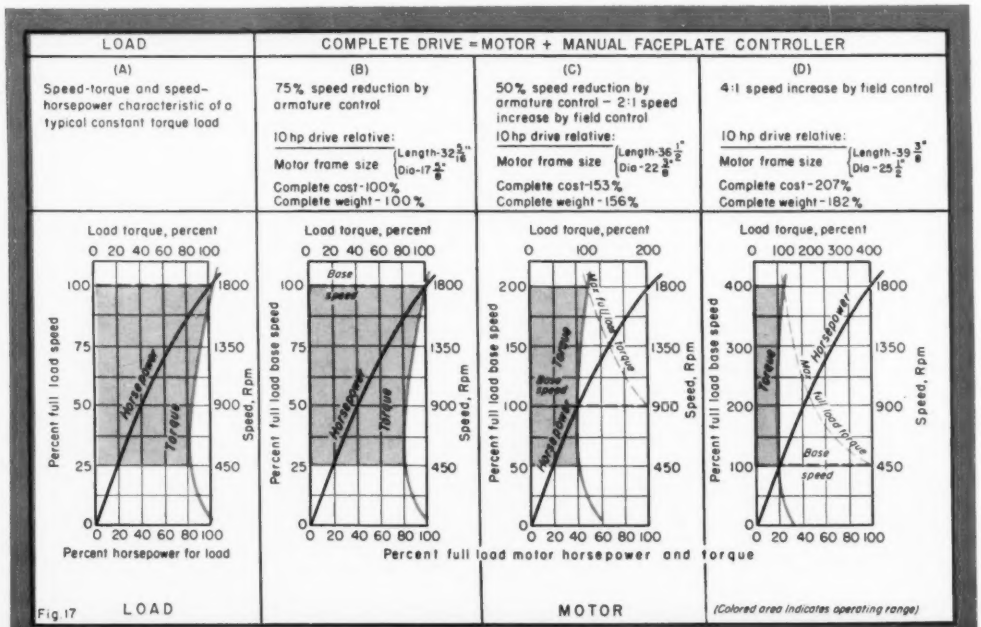


Fig. 17

shown in (A). The application of a constant speed shunt wound motor with 75 percent base speed reduction by armature resistance control is shown in (B). The drive meets the load torque requirements and is the lowest in cost, but relatively the speed regulation is very poor and the number of speed points is limited. Standard drives using armature resistance control are recommended usually for only 50 percent speed reduction. But by carefully selecting the motor and using an armature shunting resistor on the lower speed points, usually the desired speed reduction can be obtained.

A drive using a constant speed motor with speed adjustment by both armature resistance and field control is shown in (C). As shown, the armature regulating resistor needs capacity for only 40 percent of the rated horsepower at the base speed.

A drive using an adjustable speed motor for 4 to 1 speed adjustment by control of the shunt field excitation only is shown in (D). This drive gives a fairly good speed regulation and provides a relatively large number of points. The cost, weight, and size of this drive is considerably more than that of the other two; and full horsepower rating of the motor can be utilized only when the motor is operated at maximum load speed. In general, the higher the base speed of a shunt motor, the smaller the motor frame size and the lower the cost.

A graphical analysis such as illustrated in Fig. 17 is a good way to select the most economical and satisfactory drive.

A-C Motor Drives— A-C Power Source

Most electrical energy distributed in the United States is 60 cycle alternating current. Thus, generally it is more economical to apply a standard a-c motor and controller if it provides the necessary drive characteristics.

Basic Speed Formula

The speed of an a-c motor is determined by the number of poles in the field winding and by the frequency of the applied voltage to these windings. Where: $N =$ synchronous speed, rpm; $K =$ constant, 120; $F =$ frequency of power supply, cycles per sec.; and $P =$ number of poles; then the basic equation for the synchronous or maximum speed is $N = KF/P$.

Except for an a-c synchronous motor, the synchronous speed is a theoretical speed that a motor could attain only if it had no losses or load. An a-c induction motor cannot reach synchronous speed since there is no torque developed when the rotor revolves at exactly the same speed as the rotating field. The difference between the synchronous speed and the actual speed for the torque required to drive the motor and load is the "slip." The speed of an induction motor is determined also by the load and is a speed at which the motor torque output and the load torque requirements have reached a suitable equilibrium.

As shown by the speed equation, the motor speed can be varied by changing the frequency of the power supply or the number of poles in the field winding. An a-c motor always has an even number of poles so there will be the same number of north as south poles. The minimum number of poles is two. The relationship between the speed and the number of poles at given frequencies of 25, 60, and 120 cycles is shown in Fig. 18.

Speed of a motor with a given number of poles for frequencies up to 120 cycles is shown in Fig. 19. On basis of frequency adjustment, change in speed per cycle is greatest for a two pole motor and least for a 40 pole motor.

Basic Torque Formula

In general and except for some conditions of synchronous motor operation, the torque developed by an a-c motor is proportional to the square of the impressed voltage applied to the stator or field windings. Where $T =$ torque, ft lb; $K =$ motor design and conversion constant; and $V =$ voltage applied to the field of stator windings; the approximate torque equation is $T = KV^2$.

The speed of an a-c induction motor

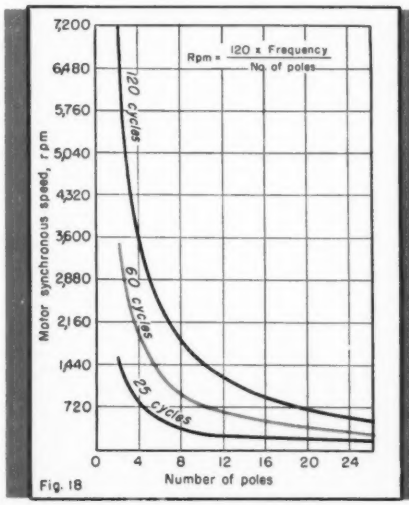


Fig. 18

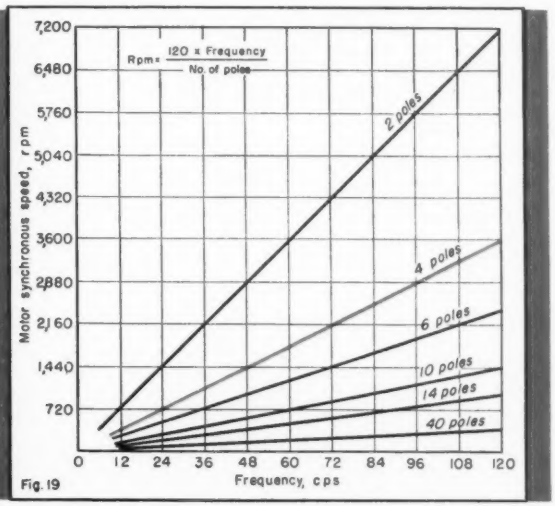


Fig. 19

can be controlled to some extent by adjusting the voltage applied to the field windings. Since change in applied voltage changes the torque output of the motor, the speed of the motor must change for a given load. Generally, this method of speed control is unsatisfactory because reducing the applied voltage may result in too low breakdown torque. For some single phase fan applications, this method of control is quite widely used. When the load characteristic is such that the horsepower requirements decrease rapidly with a decrease in speed, often voltage control is satisfactory.

A-C Squirrel-Cage Induction Motor Drives

The a-c squirrel-cage induction motors are the simplest and sturdiest of electrical rotating devices.

For integral horsepower loads, the polyphase induction motor is predominantly the most widely used type of motor for constant speed industrial drives.

For fractional horsepower loads, the single phase induction motor is the most common type of motor. Often polyphase power is not available at the places where the majority of the fractional horsepower motors are applied, such as in homes.

Squirrel-cage induction motors are essentially constant speed motors. In general, for sizeable motors there are no relatively inexpensive control methods for providing reliable speed change. About the only practical means for changing the speed of a relatively small induction motor (without changing the number of poles or the frequency of the power supply) is to change the voltage applied to the motor field. Then the motor operates at a speed that is determined by the load and the changed motor output torque characteristic.

Speed Adjustment of a Single Phase Capacitor Motor By Primary Voltage Control (Autotransformer)

Characteristics: Speed range, about 2 or 3 to 1 (50 to 33 percent speed reduction by voltage control); speed change, speed decrease from no load to full load approximately 70 to 50 percent at low speed and 5 percent at base speed; horsepower, fractional. The control for a typical motor driving a fan is shown in Fig. 20. In the circuit diagram, when the line contact *M* is closed, the motor is connected to a tap on the auto-transformer. The speed for each voltage is determined directly by the load.

The speed-torque curve for the lowest value of applied voltage has a very steep characteristic. At lower speeds its slope is similar to that of the load curve. Under this condition, unless the load requirements are known precisely, the speed at which the motor and the load torques are in equilibrium will be indefinite. The four fan operating speeds shown are satisfactory only because the fan load characteristics are such that the torque requirements droop rapidly with a decrease in speed.

Three Phase Squirrel-Cage Drive Motor Characteristics

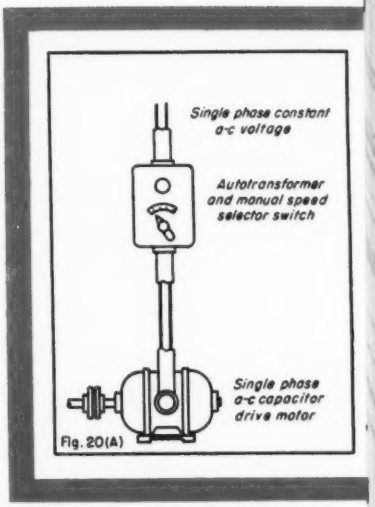
For a given a-c squirrel-cage motor, the speed-torque characteristic is determined primarily by the rotor design and resistance, as shown in Fig. 21. Linestart Class I and II motors, normal starting torque, low starting current and high starting torque, low starting current respectively, operate at a relatively constant speed and differ primarily in the starting torque that each can develop.

High-torque high-slip motors have a drooping speed-torque characteristic. This can be utilized effectively for providing automatic speed control, for high inertia applications where the load is pulsating and load peaks are large. As the motor speed automatically decreases rapidly with an increase in load, the flywheel or mass of the driven machinery can give up its kinetic energy to the load. Since the peak energy is supplied by the kinetic energy of the rotating system, the motor current peaks and power supply disturbances are reduced. These motors are used to drive pulsating loads such as encountered with a punch press or crusher. Generally, a normal or low slip (Class I or II) motor is not satisfactory on such applications because the high torque cyclic load causes overheating of the motor.

Speed Adjustment of a 3 Phase A-C Squirrel Cage Motor By Primary Resistance Control

Characteristics: speed range, from full to zero speed, the operating speed is indefinite; speed change, speed decrease from no load to full load approximately 100 percent at low speed and 3 or 4 percent at high speed; horsepower, only practical for low horsepower ratings and variable torque loads.

The output torque of a squirrel-cage induction motor can be controlled by inserting resistance in each phase of the primary circuit to reduce the voltage actually applied to the field windings.


Single phase constant a-c voltage
Autotransformer and manual speed selector switch
Single phase a-c capacitor drive motor
Fig. 20(A)

In the circuit diagram of Fig. 22, when the drum controller is on the first point, the motor is energized with all the resistance in series with each phase. Motor speed depends only on the torque requirements of the load.

The speed-torque curves for a four point controller are shown for a particular resistor design. The speed can be adjusted only in a small range approximately from 75 to 95 percent for a varying torque load.

For the constant torque load shown, the motor can be started only on the fourth controller point or with full voltage on the motor. After the motor is once started, the speed can be reduced to only 90 percent of the synchronous speed value by moving the drum back to the second point.

As shown by the circuit, the drum controller must be able to carry and interrupt relatively large primary currents. Usually, this method of speed control is very ineffective and is not satisfactory.

Speed Adjustment of a Three Phase Squirrel Cage Motor By Pole Changing Control

Characteristics: Speed range, single winding motors 2 to 1 and multiple winding motors 2 to 1, 3 to 1, 4 to 1, etc.; speed changes, speed decrease from no load to full load approximately 3 to 4 percent; horsepower, unlimited.

By reconnecting the field windings to provide two or more pole combina-

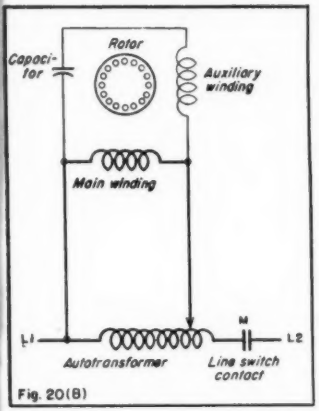


Fig. 20(B)

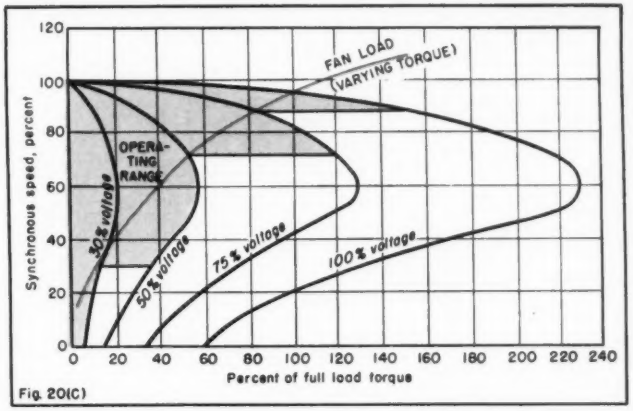


Fig. 20(C)

tions, multispeeds can be obtained from the same motor. It is impracticable to obtain speed adjustment between the synchronous speeds for the various pole combinations. But such multi-speed motors are widely applied where only two, three, or four different speeds are satisfactory, such as for fans and machine tools. Three speeds can be obtained by using only three pole combinations of a four speed motor assembly.

A typical multi-speed motor drive with a manually operated speed selector station and magnetically operated pole changing controller is shown in Fig. 23. Manually operated drum controllers can also be used for multi-speed motor control, but do not generally provide means for interlocking or overload protection for the motor.

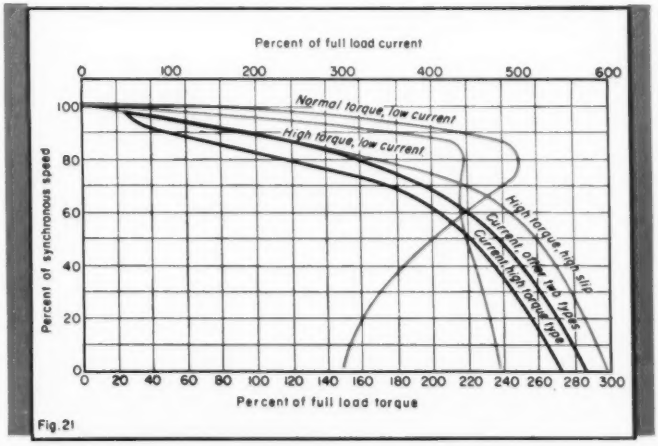
In the typical two-speed magnetic starter shown, the motor is started and operated on either speed depending upon the pushbutton operated. When a pushbutton is depressed, its respective speed contactor coil is energized and the main contacts close to start the motor and bring it to the desired speed. With this low-voltage protection type of circuit an auxiliary interlock keeps the coil energized even if the pushbutton is depressed only momentarily. The pushbuttons are electrically interlocked in such a manner that both contactor coils can not be energized at the same time. And, if the motor is operating at one speed, operation of the other speed pushbutton will de-energize one contactor coil and energize the other coil for the desired speed. For additional safety, the contactors are mechanically interlocked.

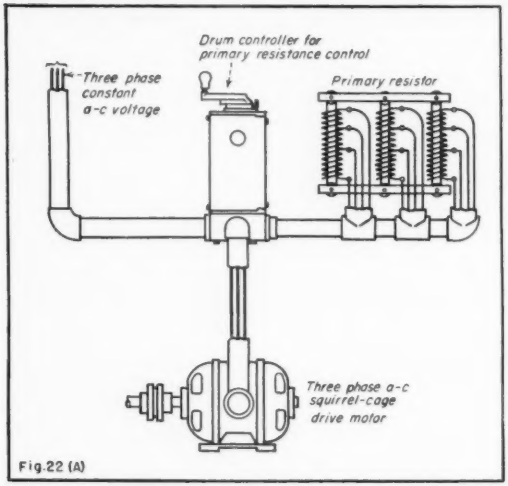
Some multi-speed starters use a "compelling" relay so that a motor can be initially started only on the lowest speed. For some applications where the driven load has a high inertia, an automatic time delay between speed changes is used to prevent damage to the motor or driven machinery.

Typical speed-torque curves for constant horsepower, constant torque, and variable torque motors are shown. The torque at low speed for a constant horsepower motor must be twice the value of the high speed torque, as shown. It is also two times the value of torque for the low speed of a constant torque motor, and four times that of a variable torque motor. The curves are based on motors that have the same rating at the highest speed and have a high to low speed ratio of 2 to 1. For motors with two separate windings, the ratio between the high and low speeds does not necessarily need to be 2 to 1.

For two speed motors with single windings, the ratio between the high and low speeds is always 2 to 1. Standard two-speed two-winding motors can have almost any high speed to low speed ratio, such as 1.33 to 1, 1.6 to 1, 2 to 1, 3 to 1, 4 to 1, etc. Three and four speed motors can have numerous pole combinations that provide a relatively large range in the speed control.

For the most satisfactory selection of a multi-speed drive motor, the precise characteristics of the load must be


Percent of full load current
Normal torque, low current
High torque, low current
High torque, high slip
Current, other two types
Current, high torque type
Percent of synchronous speed
Percent of full load torque
Fig. 21


Drum controller for primary resistance control
Three phase constant a-c voltage
Primary resistor
Three phase a-c squirrel-cage drive motor
Fig. 22 (A)

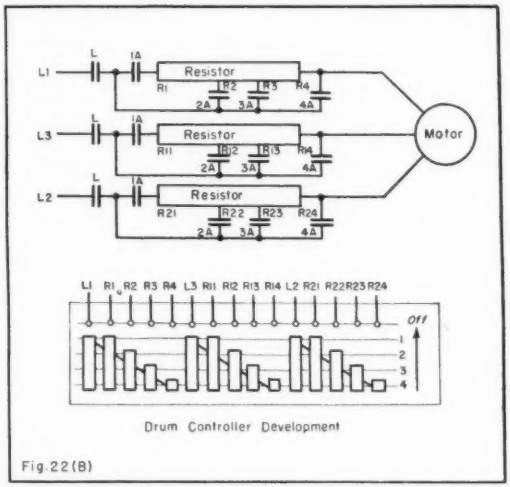


Fig. 22 (B)

known. A comparison of the horsepower ratings and physical size of 10 hp constant horsepower, constant torque, and variable torque motors is shown in Fig. 24. A variable torque motor can not be applied to a constant horsepower load since it would overheat at the lower speeds. A constant horsepower motor could be applied and carry any of the three types of load. But it would be uneconomical for constant and variable torque loads because: (1) The motor would be much larger in size than necessary, (2) have excess thermal capacity at the lower speeds, and (3) cost considerably more than the motor which has just the right capacity for the load. Also an oversize motor has relatively high moment of inertia of the rotating parts. This factor may be extremely undesirable in certain applications, such as reversing drives.

Wound-Rotor Induction Motor Drives

Applications where the wound-rotor motor often is preferable over any other type of a-c motor include: (1) When the high starting torques and low starting currents of the wound-rotor motor are required simultaneously, such as for certain pumps, compressors, and other continuous duty and constant speed applications; or (2) when speed adjustment is required such as for driving fans and conveyors and with special control equipment used for cranes and hoists.

Because of the inherent characteristics of a wound-rotor induction motor with resistance in the secondary circuit, the driven load directly determines the motor speed. The motor slip depends almost entirely upon the load; at no load the motor speed approaches synchronous speed. In general, wound-rotor motors should not be applied for very low speeds at very light loads since such conditions require special and expensive resistors. Usually, for stable operation the maximum speed reduction must not exceed 50 percent.

Speed Adjustment of a Wound Rotor Motor by Secondary Resistance Control

Manual Face Plate Control

Characteristics: Speed range, approximately 2 to 1 with 50 percent speed reduction by secondary resistance control; speed change, speed decrease from no load to full load approximately 50 percent at low speed and 5 percent at base or high speed; horsepower, unlimited.

A manually operated starting and speed regulating rheostat is generally the simplest type of controller for a wound-rotor motor. A typical wound-rotor drive motor with a magnetically operated primary starter and a manually operated secondary controller is shown in Fig. 25. Motor operated drums, magnetically operated contactor controllers, or liquid rheostats generally are used for the relatively large wound-rotor motors.

The circuit diagram for a typical manually operated starter and speed regulating rheostat is shown. The rheostat is arranged so that the motor is

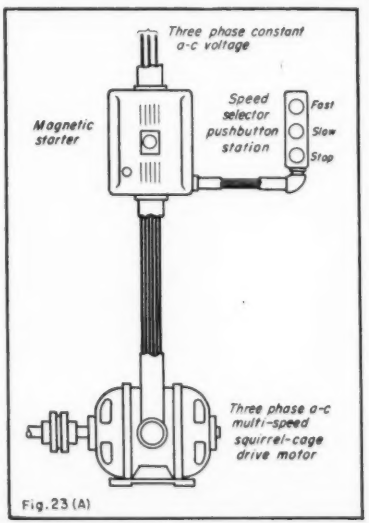


Fig. 23 (A)

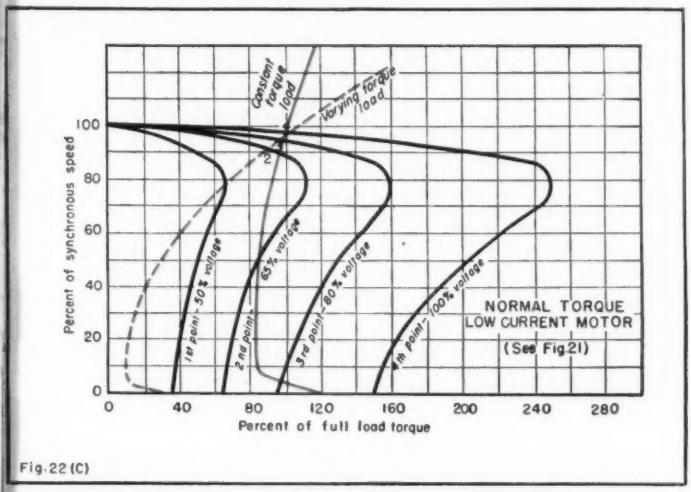


Fig. 22 (C)

always started with all the resistance in the secondary circuit. A control contact on the face plate arm momentarily provides a circuit for energizing the primary starter contactor coil. Energization of this coil closes the contacts *M* and energizes the primary circuit of the motor. The motor then operates at a speed depending upon the load and the value of the resistance in the secondary circuit.

This circuit will provide low-voltage protection and make it necessary for the controller to always be returned to its "Off" position before the motor can be restarted in case of an overload.

A typical set of speed-torque curves for a multi-point secondary resistor controller is shown. These curves are similar to those which would be obtained from a resistor designed according to the specifications for a NEMA Class No. 93 resistor for varying torque applications. With this particular resistor design, on the first point the motor will develop approximately 35 percent of its rated torque and will operate at approximately 50 percent of synchronous speed for the correct load.

For applications where "softer" starting and finer speed control are required, special controllers operate so that one phase of the secondary circuit is open on the first controller point. On single phase, a motor develops only about 50 percent of its three phase starting torque.

Within certain operating regions the speed-torque curves of a wound-rotor motor with secondary resistance control are similar to those of the d-c shunt motor operated with resistance in the armature circuit as shown in Fig. 10.

Magnetically Operated Control

Characteristics: Speed range, approximately 2 to 1 with 50 percent speed reduction by secondary resistance control; speed change, speed decrease

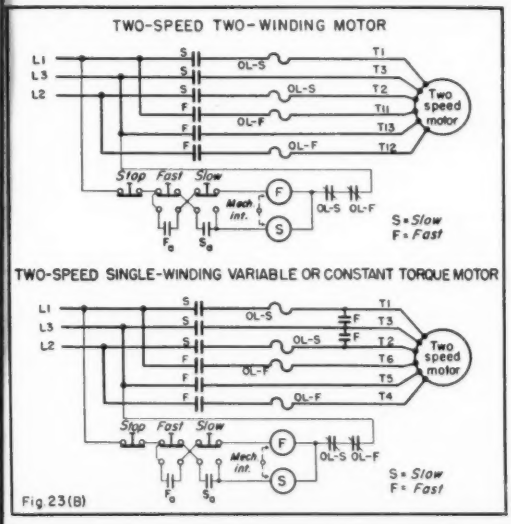


Fig. 23 (B)

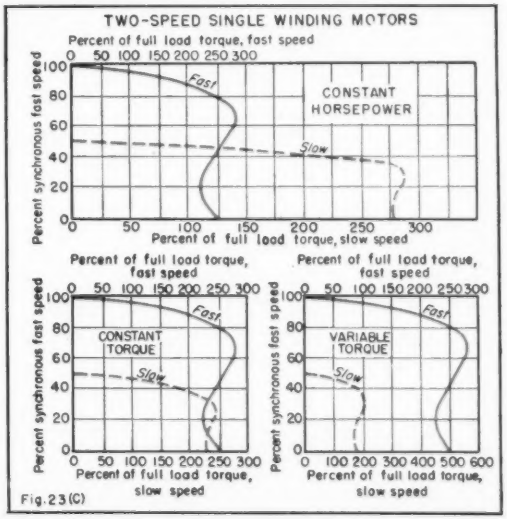
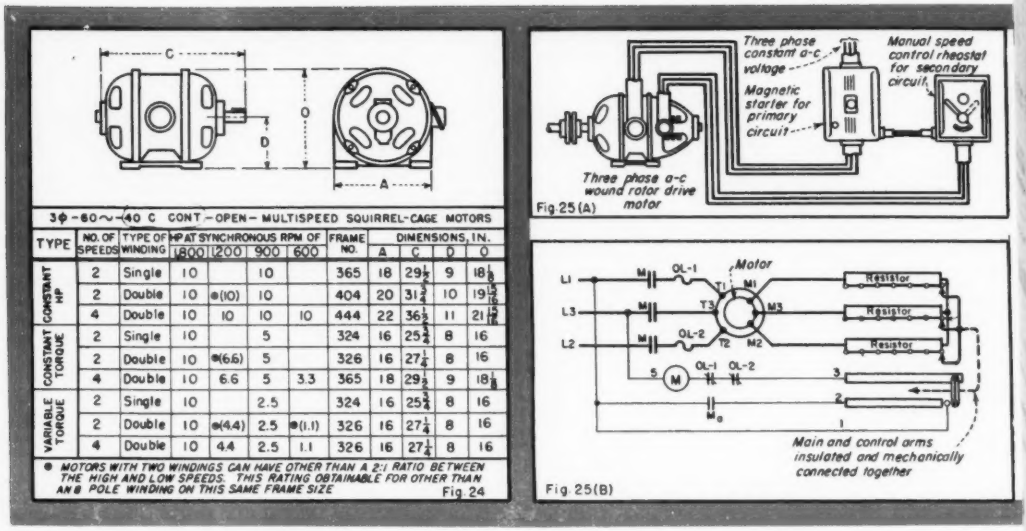


Fig. 23 (C)



3φ – 60 ~ – 40 C CONT – OPEN – MULTISPEED SQUIRREL-CAGE MOTORS

TYPE	NO. OF SPEEDS	TYPE OF WINDING	HP AT SYNCHRONOUS RPM OF 1800	1200	900	600	FRAME NO.	DIMENSIONS, IN. A	C	D	O
CONSTANT HP	2	Single	10		10		365	18	29 1/2	9	18 1/8
	2	Double	10	●(10)	10		404	20	31 1/2	10	19 1/8
	4	Double	10	10	10	10	444	22	36 1/2	11	21 1/8
CONSTANT TORQUE	2	Single	10		5		324	16	25 1/4	8	16
	2	Double	10	●(6.6)	5		326	16	27 1/4	8	16
	4	Double	10	6.6	5	3.3	365	18	29 1/2	9	18 1/8
VARIABLE TORQUE	2	Single	10		2.5		324	16	25 1/4	8	16
	2	Double	10	●(4.4)	2.5	●(1.1)	326	16	27 1/4	8	16
	4	Double	10	4.4	2.5	1.1	326	16	27 1/4	8	16

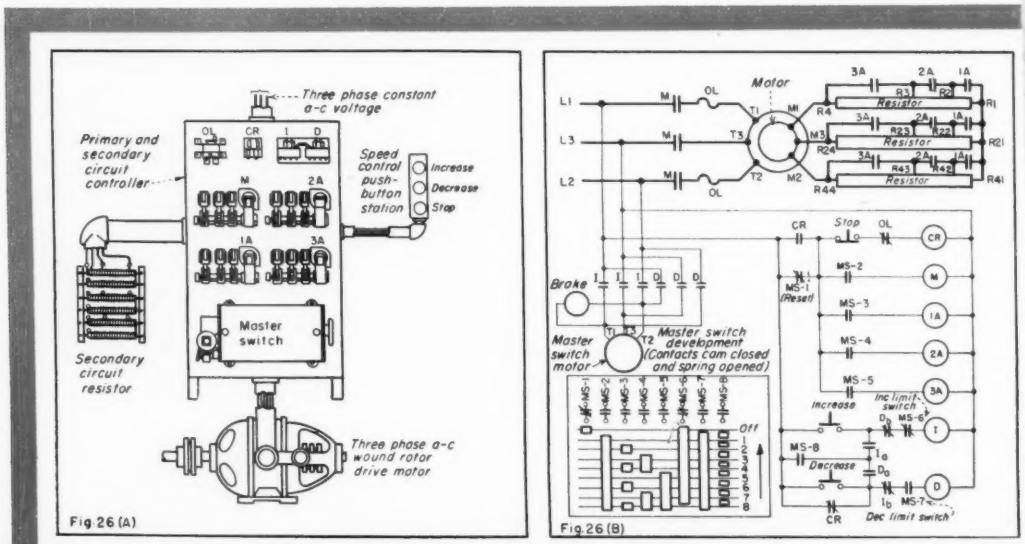
● MOTORS WITH TWO WINDINGS CAN HAVE OTHER THAN A 2:1 RATIO BETWEEN THE HIGH AND LOW SPEEDS. THIS RATING OBTAINABLE FOR OTHER THAN AN 8 POLE WINDING ON THIS SAME FRAME SIZE

Fig. 24

from no load to full load approximately 50 percent at low speed and 5 percent at base or high speed; horsepower, unlimited.

Some applications require many operating speeds and if the motor is large, many contactors may be required in the secondary circuit. Usually, the size and cost of such a controller is beyond reasonable limits. The controller shown in Fig. 26 uses only three secondary circuit contactors and a master switch to provide eight speed points. The ohmic value of the resistor steps are tapered in a geometric ratio and the secondary contactors are closed in a certain sequence. For example, for a three step secondary resistor, in terms of total resistance value: The first step will have 1/7, the second step 2/7, and the third step 4/7. To obtain 16 speed points requires 4 contactors and a 4 step secondary resistor; 32 speed points require 5 contactors and a 5 step resistor; 64 speed points require 6 contactors and a 6 step resistor, and so on.

The master switch is the "brains" of the controller, since it governs the sequence in which the contactors operate. Generally, it is motor-operated to assure more positive operation and for simple remote and automatic operation.



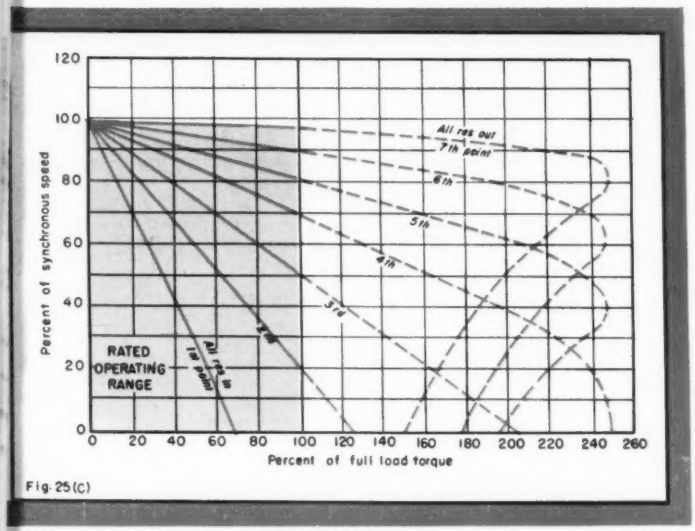


Fig. 25 (C)

When the master switch is in the "Off" position, the reset contact *MS*-1 is closed. The *CR* relay provides low-voltage protection and is initially energized through the reset contact *MS*-1. The normally open *CR* contact provides a holding circuit for the *CR* coil when the master switch is in any other position except the "Off" position. In event of an overload, operation of the "Stop" pushbutton, or voltage failure, the coil *CR* is de-energized and opens the circuit to the primary and secondary circuit contactor coils. The *CR* coil can be energized again only by returning the master switch to its "Off" position. The reset contact *MS*-1 prevents the motor from being started unless all the secondary resistance is in the circuit.

To start the motor, the "Increase" pushbutton is operated. This energizes the coil *1* and the *1* contacts close and start the master switch motor. In its first position, contact *MS*-2 closes and energizes the primary circuit contactor coil *M*. The contacts *M* close and the wound-rotor motor is started with all resistance in the secondary circuit.

If a higher speed is desired, the "Increase" pushbutton is held down. On the second master switch point, contact *MS*-3 closes and energizes contactor coil 1*A*. When the contacts 1*A* close, one unit or 1/7 of the total resistance is shorted out of the secondary circuit and the motor accelerates.

On the master switch third point, contacts 1*A* are open and contacts 2*A* are closed. Two units or 2/7 of the total resistance is shorted out. On the master switch fourth point, both contacts 1*A* and 2*A* are closed and short out three units or 3/7 of the total resistance. Contacts 3*A* only are closed on the master switch fifth point and short out four units or 4/7 of the total resistance. And so on, until all of the resistance is cut out of the circuit unit by unit on the master switch eighth point.

The master switch contact *MS*-8 functions as a notching contact in that it prevents the master switch drum from stopping between the definite speed points. To insure positive operation of the master switch, often the drum is driven through an intermittent or Geneva type of gear mechanism. A magnetically opened and spring set brake on the master switch motor shaft stops the motor on the exact points.

Speed-torque curves for a wound-rotor motor, the speed of which is controlled by cutting out equal increments of the secondary circuit resistor, is shown in Fig. 26. In this particular design, the resistance value provides 100 percent starting torque on the first point. The change in speed from one point to another, particularly in the higher speeds, is not uniform. But this is of little significance since the actual controller has a large number of speed points.

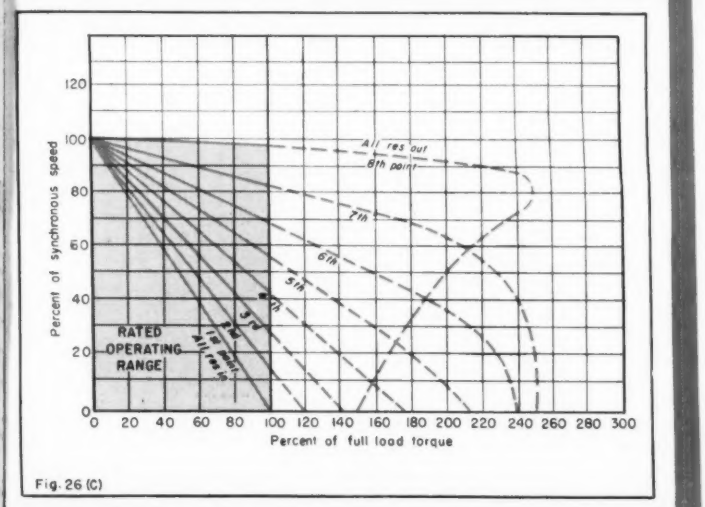


Fig. 26 (C)

Liquid Slip Regulator

Torque Motor Operated Type Control

Characteristics: Speed-range, approximately 1.07 to 1; speed change, speed decrease from no load to full load approximately 7 percent at base speed; horsepower, 1,000 to 7,000, practical range.

Liquid rheostats provide a practical means for starting and regulating the speed of very large wound-rotor induction motors. A liquid slip regula-

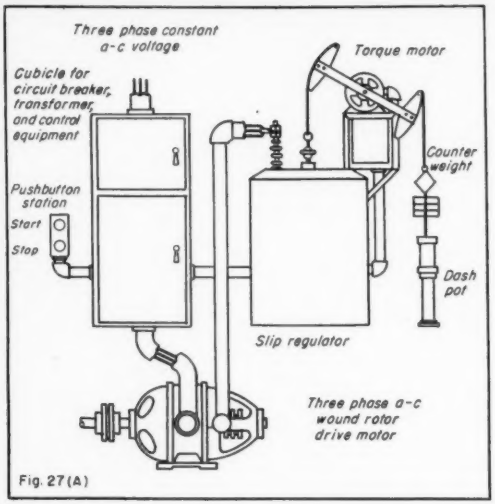


Fig. 27(A)

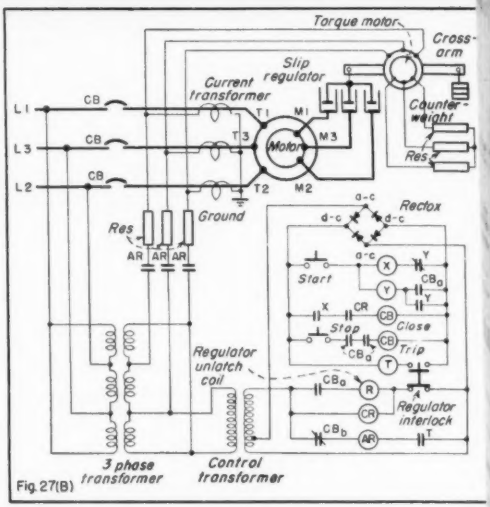


Fig. 27(B)

tor is essentially a liquid rheostat with automatic control for maintaining a preset value of motor current or power input.

Generally, it is used for motors that have fly-wheels. For example, large a-c to d-c motor-generator sets are usually required for furnishing the d-c power for rolling mills and mine hoists. Since the loads for mine hoists and rolling mills are cyclic, a fly-wheel on the m-g sets store energy during the low power demand periods and gives up energy during the peak power demand periods. Thus, power requirements of these applications can be maintained approximately constant with a liquid slip regulator.

Basic elements of the liquid slip regulator shown in Fig. 27, are a heavy sheet steel tank, three stationary and three movable electrodes, electrolyte, a cooling system, and a torque motor for raising the movable electrodes. The three movable electrodes are mechanically and electrically connected to a cross-beam that can be raised by the torque motor. Energy for the torque motor is from a three phase series transformer connected in the primary circuit of the wound-rotor motor. The complete moving system is mechanically balanced so that at light loads, the force produced by the weight of the movable electrode assembly slightly exceeds the restraining force of the torque motor. In the "Off" position, the cross-arm on the torque motor shaft is mechanically latched in the position for maximum electrode separation. When the cross-arm is unlatched, the weight of the movable electrode assembly moves the electrodes into the electrolyte, thus decreasing the resistance in the secondary circuit of the motor. If the main motor current increases beyond a preset value, the torque motor raises the electrodes and increases the secondary resistance to reestablish equilibrium. The dash-pot assembly prevents hunting of the regulator when the motor is first started. It has two different piston diameters. In normal operating range

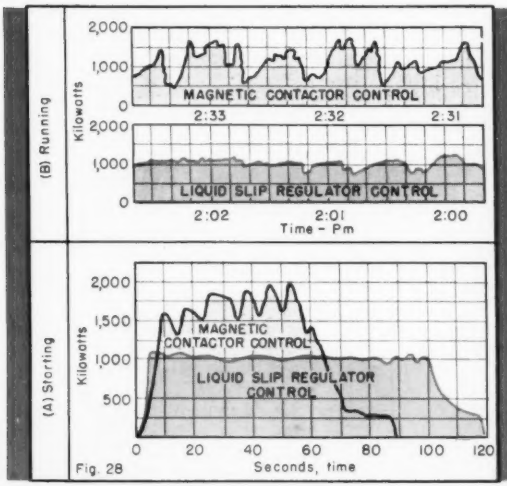


Fig. 28

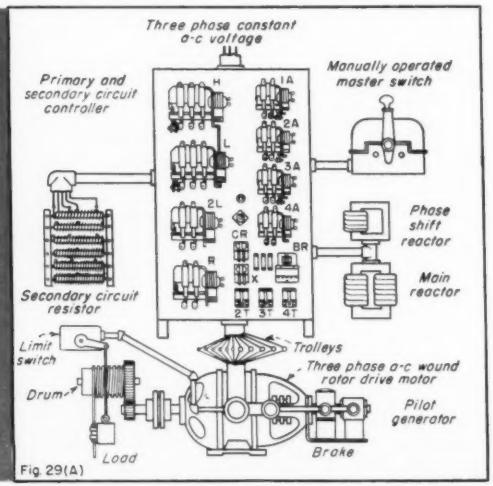


Fig. 29(A)

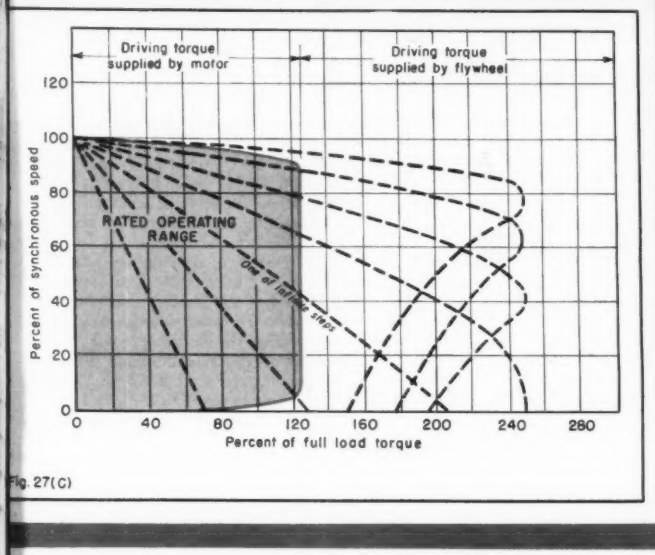


Fig. 27(C)

of the regulator, the dashpot is ineffective since the piston is loose in the upper cylinder.

A simplified circuit with automatic reset control is shown.

In the regulator "Off" position, the relay coil *CR* is energized through an interlock contact which is closed only when the cross-arm on the torque motor shaft is in the "Off" position. The *CR* contact in series with the circuit breaker closing coil *CB* prevents the main primary breaker from being closed unless the electrodes are fully separated. To start the main motor, the "Start" pushbutton is operated to energize coil *X*. The closing of contact *X* energizes the circuit breaker closing coil *CB*. The circuit breaker contacts *CB* in the main motor primary circuit close and the motor starts with maximum resistance in its secondary circuit. When the circuit breaker closes, an auxiliary interlock contact CB_a on the breaker closes and energizes coil *Y*. When the normally closed *Y* contact opens, coil *X* is de-energized and the *CB* closing coil circuit is de-energized. This relay scheme prevents the circuit breaker closing coil, (which usually is intermittently rated), from being energized any longer than necessary to fully close the breaker regardless of how long the "Start" pushbutton is held down. Auxiliary contact CB_a on the breaker closes and energizes the regulator unlatch coil *R*. Releasing of a mechanical latch on the cross-arm by a magnetic solenoid that is energized by coil *R* permits the electrodes to descend into the electrolyte by their own weight. Movement of the cross-arm actuates the regulator interlock contacts which de-energize coils *R* and *CR* and energize the inductive timing relay coil *T*.

The main motor is accelerated to normal speed with constant current control. At full speed, the movable electrodes are very close to the stationary electrodes and the resistance of the secondary circuit is a minimum. The minimum resistance of the regulator adds about 2 percent more to the normal slip of the motor when it is operating at full speed. If a load is suddenly applied to the motor, the speed will decrease in a normal manner until the point is reached where the regulator becomes effective. Then, the speed drops abruptly and the fly-wheel releases energy to the system.

The speed-torque characteristics of a wound-rotor motor when the regulator is calibrated to limit the current to about 125 percent of the full load value is shown in Fig. 27. Light load periods must be long enough so the motor can bring the fly-wheel up to its maximum speed.

Usually the conductivity of the cold electrolyte (generally a 3 percent solution of water and sodium carbonate Na_2CO_3) is of such value that the primary starting current is about 70 percent of the full load value. The particular speed of the motor at which the current reaches its maximum is determined by how fast the electrodes descend in the electrolyte and the mass

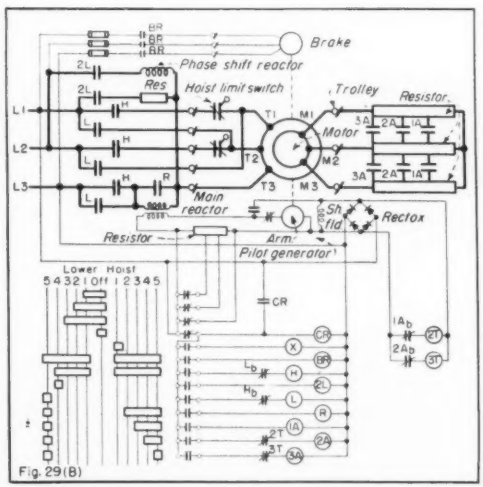


Fig. 29(B)

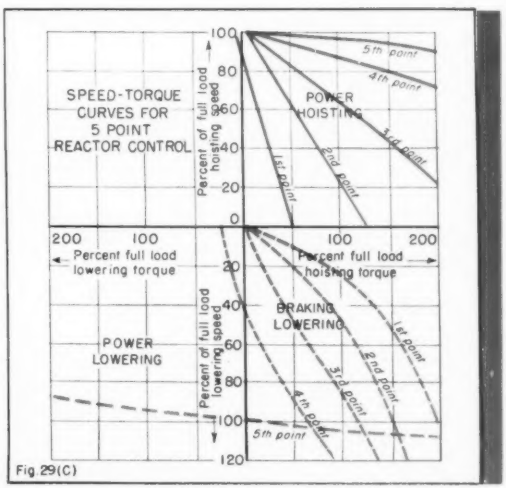


Fig. 29(C)

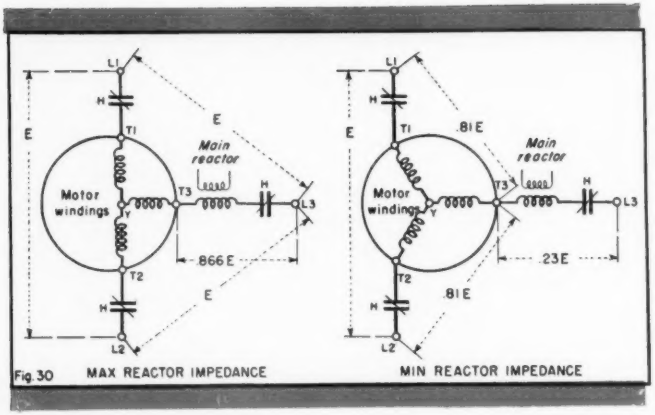


Fig. 30 MAX REACTOR IMPEDANCE MIN REACTOR IMPEDANCE

of rotating system in the m-g set.

A metallic resistor could be used to give the motor the necessary drooping characteristic for efficient use of a flywheel. But that is a very inefficient method compared to a liquid slip regulator that inserts resistance in the circuit only when it is required. Also, the slip regulator gives gradual and stepless speed changes.

Compared to a magnetic controller for a 2,000 hp plate mill motor, the reduction in peak power demands with a slip regulator on starting is shown in Fig. 28. The starting period is naturally longer, but usually this is not important since the m-g set operates continuously.

For a particular 1,500 hp sheet mill motor application, the peak running power demand with magnetic contactor control was approximately 1,800 kw. Under similar load conditions and with liquid slip regulator control, the maximum peak kw demand was only 1,300. During the most severe load conditions on the mill, the peak power demands were reduced from 2,400 to 1,700 kilowatts.

Power companies base their energy charge rates on maximum power demands. For some applications, the electrical energy charges can be held to a minimum by employing a liquid slip regulator.

Reactor Control for Overhauling Loads

Characteristics: Speed range, indeterminate as speed depends entirely upon the load; speed change, speed decrease from no load to full load approximately 100 percent at low speed and 5 percent at base speed; horsepower, 5 to 300 intermittent.

Recently developed reactor type controllers for wound-rotor motors are used for crane hoists and similar applications where a variety of loads is handled in a wide range of speeds. It is well suited for applications that require lowering of overhauling loads without the use of mechanical load brakes. This type of control system provides: (1) Better control in lowering all types of loads, particularly heavy loads, at lower speeds than is possible with the usual type of a-c hoist controller; (2) a minimum speed of approximately 20 percent of full load speed when lowering full load or more; and (3) precision lowering and inching movements.

Basic requirements of a crane hoist drive are: (1) Hoist all normal loads at low, medium, or high speeds; (2) hoist very light loads at reduced as well as high speeds; (3) lower all loads at slow, medium, or high speeds; (4) provide a "creeping" speed through the normal range of loading for careful spotting of critical loads; (5) lower non-overhauling light hook loads at both low and high speeds; and (6) keep the motor current at a minimum to reduce the motor heating throughout all operations. Most of the conventional a-c hoist controllers meet only some combination of four of these requirements. The reactor system, which applies variable unbalanced voltages to the motor primary by the automatic control of reactors, meets the basic requirements satisfactorily. This control system does not require a special design of hoist motor.

A simplified reactor controller is

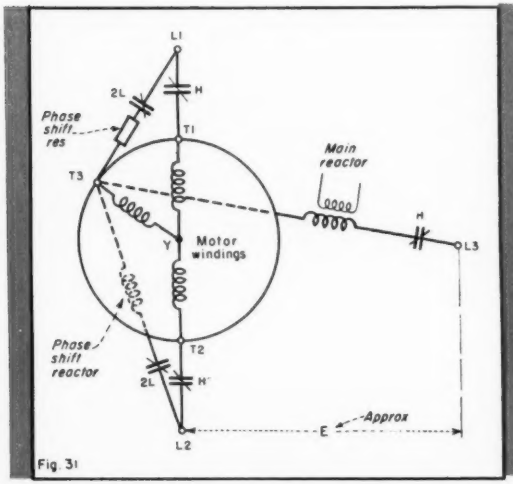


Fig. 31

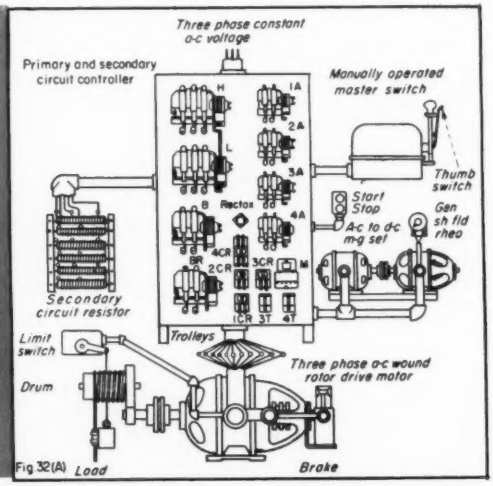


Fig. 32(A)

shown in Fig. 29. This drive uses trolley wires and collector shoes for movable electrical connections, and a hoist limit switch to limit overtravel.

Primary circuit voltage unbalance is created by a saturable reactor in one of the three phase lines, as shown. The degree of unbalance is varied by changing the reactance of the main reactor. With low reactance, unbalance is negligible and the motor operates normally. Maximum motor torque is obtained under these conditions. The greater the reactance, the greater the voltage unbalance, and the less the torque.

The magnitude of the reactance is continuously varied by the use of saturable-core reactors in which the d-c excitation determines the a-c reactance. The d-c excitation is proportional to the motor speed and is also automatically controlled. The reactor produced unbalanced voltage system is used for hoisting loads at creeping speeds. Otherwise, this unbalanced voltage control has no other function in the hoisting operation.

For simplicity in showing the principle of the control a direct connected d-c pilot generator supplies a voltage that is directly proportional to the hoist motor speed. On actual controllers, instead of a pilot generator, a static type of speed detector in the motor secondary resistor circuit which is responsive to the slip frequency and motor speed is employed. This works in conjunction with a bias voltage and an amplifier system. Master switch contacts are cam closed and spring opened.

When the master switch is moved to its 1st point in the hoisting direction, relay coil X is energized and contacts X excite the d-c winding of the main reactor with a relatively high value of direct current. The BR relay coil is energized, its contacts close, energizes the thrustor type brake, which releases. When the main line contactor H closes its contacts, unbalanced voltage is applied to the motor. The motor now develops minimum starting torque; whether the motor starts, depends upon the load. Because of voltage unbalance, the motor runs at a sub-synchronous speed at no load. In a typical drive, the motor current that flows through the main reactor varies from about 5 percent of full load motor current at maximum impedance to about 85 percent at minimum impedance.

Fig. 30 shows the vector diagrams and approximate magnitude and phase of the voltages on the motor windings at maximum and minimum reactor impedance. The a-c reactance of the main reactor is a maximum when the d-c excitation current is a minimum, and the reactance is a minimum when the d-c excitation current is at its maximum saturation value.

The 2nd point in the hoisting direction energizes coil R, the contacts of which short out the main reactor. The primary circuit of the motor is now energized with a balanced three phase voltage and the hoisting torque is in excess of full load torque at standstill. Points 3 and 4 short out more secondary resistance. On the 5th or last point hoist, all resistance is cut out of the secondary circuit after the time period of the $3T$ timing relay has elapsed.

The first three speed points in the hoist direction are controlled directly by the master switch. The last two magnetic points are also controlled by the master switch but have definite time limit relays to insure proper acceleration regardless of how the master switch is operated. The 1st point provides a relatively low torque for easy starting of light loads, but the operator can go directly to the 2nd or 3rd points if he has a load that might cause overhauling on the first controller point.

When lowering on the 1st three master switch points, the motor develops a counter torque. This opposes an overhauling load; it is governed by the main saturable reactor so that the retarding torque is zero at standstill and increases with motor speed.

The torque also is governed by the master switch so that the lowest lowering speed occurs on the first point and increases as the master switch is advanced. On the first three points the resistance is made effective in the pilot generator circuit to reduce the saturating current. A reduction in the d-c excitation current increases the motor speed for a given load.

If the load is too light to overhaul the motor on any of the first three master switch points, the master switch can be moved to the fourth point where the motor will now produce a lowering torque and slow speed operation. Contactor $2L$ closes on the 4th point and connects a phase shifting reactor and resistor into the circuit. This phase shifting circuit changes the voltage phase sequence on the motor as shown in Fig. 31 and also reverses the motor direction of rotation.

The retarding torque increases automatically with an increase in speed

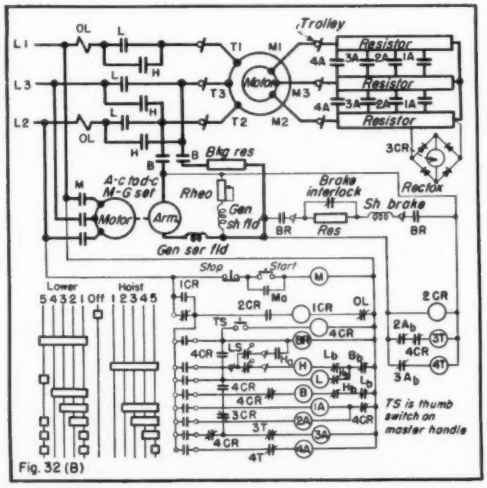


Fig. 32 (B)

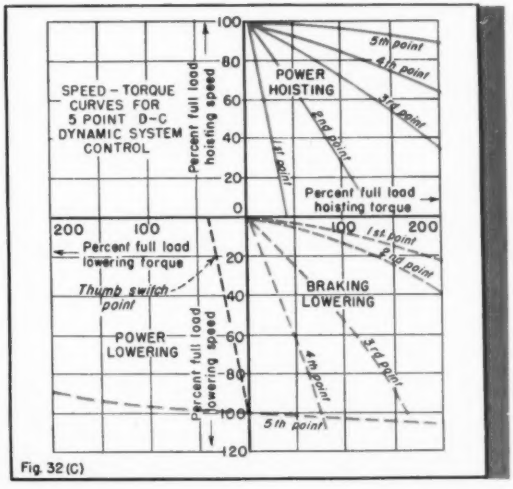


Fig. 32 (C)

and prevents over-speeding on any load not in excess of full load on any controller lowering point.

On the 5th point lowering, contactors *H* and 2*L* open. Contacts *L* and *R* close. Now the motor drives the load downward and accelerates rapidly to full speed. After appropriate time delay periods, all resistance is cut out of the secondary circuit. Thereafter, the motor lowers regeneratively and maintains the speed at approximately the full load value.

The characteristic of the motor in increasing its retarding torque with increase in speed results from changing the motor from approximately single phase operating characteristics for light loads to three phase characteristics for heavy loads. The variable impedance reactor functions to block out three phase voltage from the motor at low speed (high impedance) but yet permits the application of three phase voltage at high speed (low impedance).

Typical speed-torque curves of a wound-rotor induction motor controlled by a reactor and secondary resistor controller are shown in Fig. 29.

D-C Dynamic Control for Overhauling Loads

Characteristics: Speed range, indeterminate as speed depends entirely upon the load; speed change, speed decrease from no load to full load approximately 100 percent at low speed and 5 percent at base speed; horsepower, 5 to 300 intermittent.

These d-c dynamic system controllers are used with wound-rotor motors on crane hoists and similar applications when: (1) A variety of loads must be handled in a wide range of speed; and (2) when d-c power is available, or (3) an a-c to d-c conversion unit can be accommodated. With this controller, a minimum of 5 to 10 percent of full load speed is obtained when lowering full load or more. No mechanical load brake is necessary.

A typical d-c dynamic system controller is shown in Fig. 32. The spring-set and magnetically-released brake holds the load when the controller master switch is in the "Off" position.

To hoist a load, the master switch is moved to the 1st point in the hoist direction. This energizes the hoisting directional contactor coil *H* and the coil *BR*, which energize the motor and release the shunt brake. The motor now develops minimum starting torque with all the resistance in the secondary circuit. The hoisting torque can be controlled manually through the first three points on the master switch. The last two secondary circuit accelerating contactors have time limit relays to insure proper acceleration of the motor. On the 5th point hoist, all resistance is cut out of the wound-rotor motor secondary circuit. To give the operator complete control for holding any load when starting from rest, time delay relays are not used with the accelerating contactors 1*A* and 2*A* on the 2nd and 3rd master switch points.

When lowering a load on the first four master switch points, the primary winding of the wound-rotor motor is energized with d-c. On the 1st point in the lowering direction, all secondary resistance is shorted out of the circuit and contacts *B* and *BR* are closed. With the motor primary winding excited with d-c, the motor develops a retarding torque as soon as the overhauling load turns the rotor of the motor. This retarding torque increases very rapidly with an increase in speed. Moving the master switch to the 2nd point inserts part of the secondary resistance into the circuit and the retarding torque increases less rapidly with an increase in speed. This retarding torque relative to the torque developed on the first point increases less rapidly with speed on the succeeding points.

When the load is too light to overhaul the drive, or for lowering a light hook, the thumb switch *TS* on the master switch handle is operated to positively drive the load downwards. If the drive motor should accelerate to a relatively high speed, the voltage drop across the section of the secondary resistor to which the Rectox is connected will decrease and 3*CR* relay will drop out. The operation of the 3*CR* relay will eventually cut all resistance out of the motor secondary circuit.

On the 5th point in the lowering direction, the d-c excitation on the motor primary winding is cut off and the *L* contactor is energized. The motor then drives the load downward and accelerates rapidly to full speed. Thereafter, the motor lowers a load regeneratively, maintaining the speed at approximately normal full load value and returning power to the line.

Light or heavy loads can be lowered at full speed in this manner and decelerated to low speeds very precisely by moving the master switch towards the 1st point. The low speed may be maintained for landing or any other purpose as long as desired without any tendency for the motor to reverse, since at zero speed the motor does not develop any retarding torque at all. When the primary winding of the motor is energized with d-c, the motor functions as a generator and any mechanical rotation of the rotor is opposed by an electrical torque.

This drive is more expensive than the reactor controller illustrated in Fig. 29, but it does provide lower lowering speeds than the other controllers. Typical speed-torque curves for hoisting and lowering with the d-c dynamic system are shown in Fig. 32. The speed-torque characteristic line for the thumb switch point is shown dotted and for all secondary resistance in the circuit.

A-C Synchronous Motor Drives

An a-c synchronous motor operates at absolutely synchronous speed. There are no simple or inexpensive means for adjusting the speed of a synchronous motor.

The synchronous speed can be changed only by adjusting the frequency of the impressed voltage or by changing the number of poles. Unless a number of synchronous motors are required for a particular application, usually it is not practicable to provide an adjustable frequency power system. Synchronous motors are sometimes arranged so that the windings can be connected for several different pole combinations.

Compared to the other starters for various types of a-c motors, the synchronous motor controller is more complicated as it must control and synchronize both the a-c and d-c circuits.

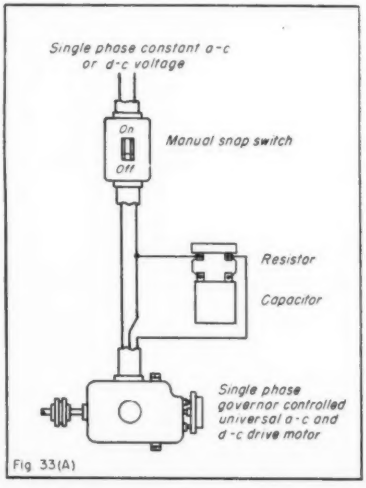


Fig 33(A)

A-C and D-C Universal Motor Drives—A-C or D-C Power Source

The Universal motor is a series wound, commutator type that operates on a-c or d-c power. The performance and operating characteristics are essentially the same on either power supply; and the speed-torque characteristic is similar to that for a d-c series wound motor.

Universal motors usually are built with fractional horsepower ratings. They develop a relatively large starting torque and may have no load speeds as high as 10,000 or 20,000 rpm. Some degree of speed control can be obtained by a series rheostat or by the use of a tapped series field. (See PRODUCT ENGINEERING, May 1948, p. 130.)

Universal motors have laminated armatures and stators so that they will operate satisfactorily on either a-c or d-c power. For a given motor assembly, the armature will rotate in the same direction on either a-c or d-c. When operated on a-c, the direction of the current in the armature circuit and the direction of the series field flux reverse simultaneously; therefore, the average torque output is in the same direction, and the rotation continues as it did for the d-c current.

Speed Adjustment of a Universal Motor by Centrifugally Operated Governor

Characteristics: Speed range, approximately 12 to 1 (typical design gives 500 to 6,000 rpm range; other designs give different ranges); speed change, speed variation from no load to full load approximately ± 2 percent; horsepower, 1/50 to 1/10.

By a centrifugal governor contact assembly mounted on the shaft, the universal motor can provide a constant speed-torque characteristic from no-load to approximately 150 percent of full-load torque. A typical universal drive motor with a centrifugal governor for speed adjustment and control is shown in Fig. 33. A screw on the governor adjusts the constant output speed value and is normally accessible only when the motor shaft is at standstill. Some governor assemblies can be adjusted while the motor is running.

When energized, the motor armature accelerates to a preset speed. The governor contacts open and insert resistance in series with the motor armature and field. The introduction of resistance in the circuit reduces the speed. When the motor speed drops to a certain value, the governor contacts reclose and the motor again accelerates to the preset speed. The capacitor in parallel with the governor contacts improves the contact life.

In operation, the governor contacts open and close rapidly, at approximately 100 to 200 times per second. The rate depends upon the natural resonant frequency of the moving contact. The contact vibration is thought to be maintained by the explosive force of the arc.

The speed-torque curves for an universal motor with and without a governor for adjusting and maintaining the output speed constant are compared. With governor control, the extremely high no load motor speed characteristic is eliminated without affecting the starting torque. This type of drive is economically applied to such machines as electric typewriters, calculating machines, and similar electrically driven office machinery, motion picture cameras and projectors.

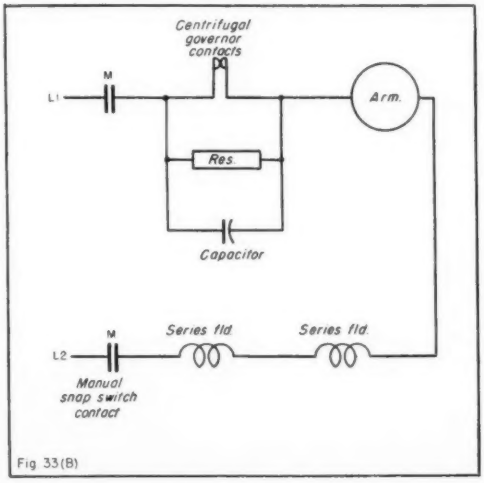


Fig. 33(B)

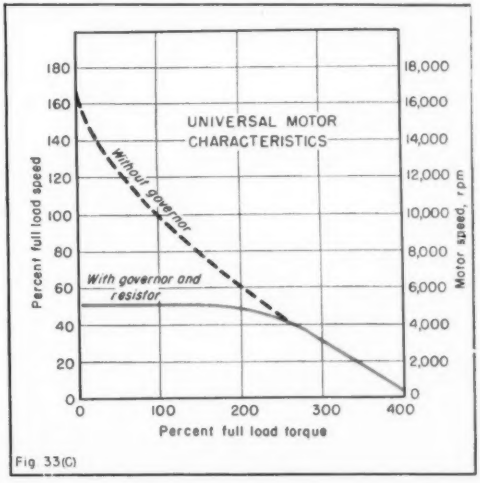


Fig. 33(C)

D-C Motor Drives—A-C Power Source and Conversion Equipment

Despite the fact that the electrical energy distributed in the United States today is predominatly 60 cycles a-c, more d-c drives are being applied than ever before. Although a-c drives are inherently simple, no satisfactory method has yet been developed to make them adjustable over the wide range that is obtainable with certain d-c drives.

Some recently developed d-c drives are very simple, but have some limitations; other more complicated systems give speed ranges as great as 120 to 1. The d-c motor is unequaled for speed range and flexibility of control.

Cost of an adjustable speed drive operating from an a-c power source is relatively high. The high first cost of this type of drive often can be saved in the design of the driven machine by elimination of gears, cone pulleys, belts, and other complicated mechanisms. Because of such advantages it is often used even for fractional horsepower motors. Adjustable speed drives are extensively used for driving paper and rubber mill machinery, winders, machine tool drives and hoists.

Some adjustable speed drives provide regenerative braking. Although not stressed in this article, regenerative braking is an important feature that should always be considered on large drives.

Series Adjustable Voltage Drives

Characteristics: Speed range, 10 to 1, with 90 percent speed reduction by armature voltage control; speed change, speed decrease from no load to full load approximately 15 percent at low speed and 25 percent at base or top speed; horsepower, up to 15.

An adjustable speed drive using a series generator and series motor is one of the simplest systems for adjustable speed operation over a wide speed range from an a-c power source.

A typical series drive is shown in Fig. 34. The d-c series generator is usually driven at constant speed by an a-c squirrel-cage induction motor. This system is satisfactory for drives requiring a wide speed range with reasonably good regulation and when the motor operates mainly in one direction.

The idealistic speed—current characteristic of a series motor operated from a series generator is shown in Fig. 35. The low voltage of the series generator at low values of current limits the inherently high no-load speed of a series motor. Conversely, the relatively high voltage of the series generator at high currents increases the normally low speed of a series motor, which is heavily loaded.

The only control equipment required consists of an a-c linestarter, a start-stop pushbutton, and a speed adjusting rheostat, as shown in Fig. 34. Depressing the "Start" button energizes coil *M*, closes the *M* contacts, and starts the a-c to d-c m-g set. As the series generator is accelerated to rated speed, the d-c series drive motor also is started and accelerated. This method of starting is like a magnetic cushion that prevents shock and undue mechanical strain on the driven load during the accelerating period.

The speed of the series d-c driving motor is adjusted by changing the setting of the generator field rheostat. With maximum resistance, generator voltage and motor speed are a maximum. As the rheostat resistance in parallel with the generator field is reduced, the voltage is decreased and the motor speed is reduced. Once the rheostat has been set for the desired speed, the drive can be started and stopped without touching the rheostat. The driving motor will accelerate to the selected and desired speed after the "Start" pushbutton has been operated. This drive provides constant torque drive characteristics; regenerative braking is not feasible. Shunt wound d-c motors speed up about 10 percent as the shunt field heats up. In this drive the speed of the series motor does not change appreciably from cold to hot operation.

The generator rheostat is the chief factor limiting the economical size of a series drive. Since at low speeds it must shunt up to 95 percent of the full load current, the rheostat must have low resistance and should be mounted reasonably close to the m-g set.

Typical speed-torque curves are shown in Fig. 34, which were secured by shunting the generator field current through the rheostat. The top curve is the speed-torque characteristic obtained when the generator is operating at full field excitation. Low speed curves are practically flat except for a rather abrupt increase in speed at very light loads.

The speed regulation is relatively poor. But for most applications, the speed regulation is good enough since friction in the driven load generally prevents the motor from operating at extremely light loads.

With the rheostat set for 10 percent of the full load base speed, the drive motor can exert a starting torque of five or six times the full load torque. Also, the drive can actually be operated at 5 percent of the base speed for short periods for threading or inching. Continuous operation at extremely low speed will overheat the motor because of decreased ventilation.

A modified and refined revision of the series drive (PRODUCT ENGINEERING, Dec. 1947, p. 128) was recently used for the regulating wheel drive of a centerless thread grinder and has a substantially flat speed-torque characteristic over a 10 to 1 speed range. By using a full wave rectifying bridge circuit across both the generator and motor fields, the fields are separately excited and the speed-torque characteristics are practically flat for all values of load.

Self-Excited Shunt Adjustable Voltage Drives

Characteristics: Speed range, 12 to 1 with 67 percent speed reduction by armature voltage control and 4 to 1

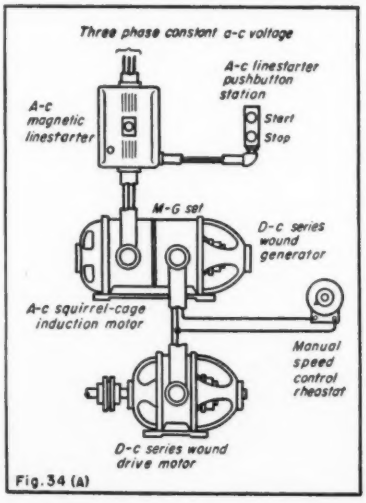


Fig. 34 (A)

speed increase by field control; speed change, speed decrease from no load to full load approximately 20 percent at low speed, 10 percent at base speed and 25 percent at high speed; horsepower, up to 15.

The self-excited shunt adjustable voltage drive, shown in Fig. 36, is another simplified form of the adjustable voltage group of drives. The generator must provide stable operation at reduced voltage while operating self-excited. On repeated operations, a stable generator produces about the same output voltage each time. Generally, the generator for a self-excited drive is designed to have field saturation at a relatively lower voltage than a standard generator. Thus, stable operation can be obtained over a voltage range of at least three to one. An ordinary self-excited generator controlled by a standard rheostat is stable to approximately 60 percent of rated voltage at no load and allows operation over a voltage range slightly less than two to one.

The d-c shunt motor for this particular drive differs from a standard motor in that the shunt field must provide full excitation with only one-third of the rated output voltage of the generator on the motor field. This is necessary if the speed of the system is to be three to one by armature voltage control. Since a self-excited shunt generator does not build up voltage quickly, usually the m-g set starts without load.

Usually the m-g set is run continuously and the d-c drive motor is started and stopped by the *L* contactor in the d-c circuit shown in the diagram. A field relay *FA* insures that when the line contactor *L* is open the motor has full field and the generator has minimum field. When contactor *L* closes, the field relay operates and increases the generator excitation and weakens the motor field to accelerate the motor to the speed determined by the rheostat setting. Also, if the armature current exceeds a preset value, the series coil *FA* on the field accelerating relay increases the motor field and decreases the generator output voltage automatically so that the desired current value is maintained.

Dynamic braking stops the drive motor quickly. The braking resistor is connected across the drive motor armature by a normally closed contact on the *L* contactor. As the motor field is continuously energized, the motor will operate as a generator when it is paralleled with a resistor.

Separately Excited Shunt Adjustable Voltage Drives

Characteristics: Speed range, 40 to 1 with 90 percent speed reduction by armature voltage control and 4 to 1 speed increase by field control; speed change, speed decrease from no load to full load approximately 50 percent at low speed, 10 percent at base speed, and 25 percent at high speed; horsepower, unlimited.

The conventional adjustable voltage drive (Ward Leonard System), Fig. 37, is more expensive than the series drive. But the increased cost is justified for many applications since the speed range is approximately four times greater than that for the other drive.

This drive was originally developed and used for large machines of several hundred to several thousand horsepower where it was impracticable to close or open the main armature circuits. Also, for some large d-c motors, such as used in steel mills, this method of motor starting and speed control is used since no contactors yet developed can carry the current in the motor armature circuit.

The exciter provides much lower excitation voltages than obtainable from self-excited generators.

The circuit for a moderately rated adjustable voltage drive is shown in Fig. 37. The m-g set a-c drive motor is started by operating the "Start" pushbutton to close the *M* contactor. For many applications it is convenient to control the starting and stopping of the d-c drive motor by means of the *L* contactor in the d-c circuit. A field accelerating relay is generally used to control the motor acceleration when the speed range obtained by field weakening is greater than 2 to 1.

For applications where the drive motor is relatively large, the line contactor *L* is omitted. (See PRODUCT ENGINEERING, July 1947, p. 167.) The generator and motor field rheostats are electrically connected in the controller so that the generator rheostat must be set for operating the generator at a low voltage before the motor can be started. The speed of the motor is adjusted first with the generator field rheostat and then with the motor field rheostat. These rheostats are often motor operated for remote or automatic operation.

For reversing a large d-c motor, the generator field is reversed. Typical speed-torque curves for the separately

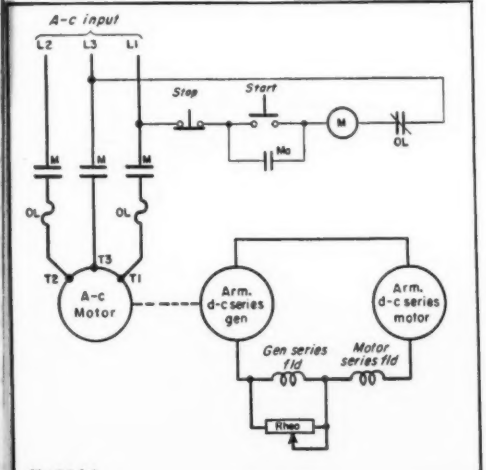


Fig.34 (B)

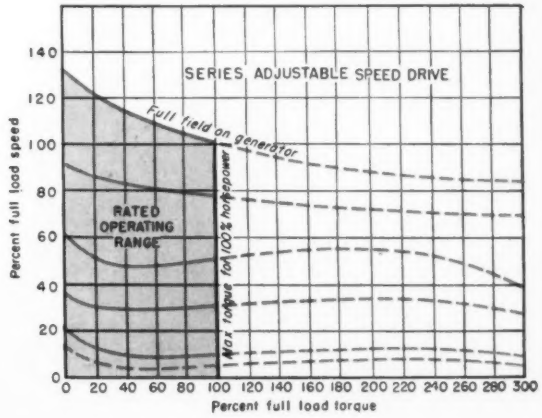


Fig.34 (C)

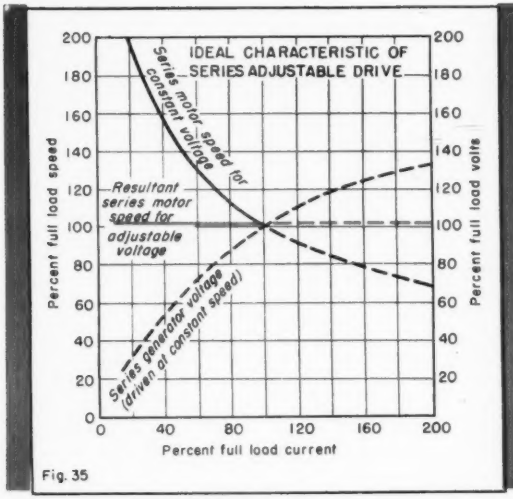


Fig. 35

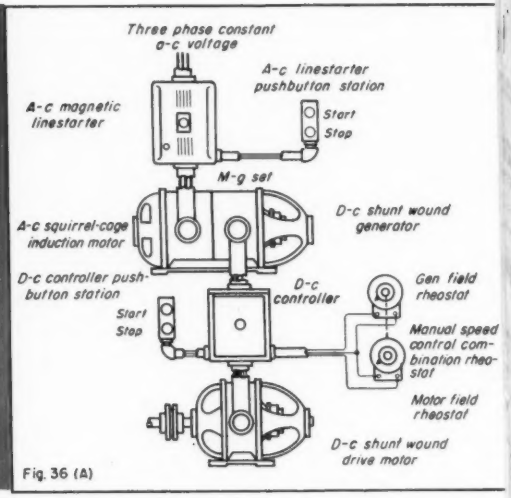


Fig. 36 (A)

excited adjustable voltage drive are shown in Fig. 37. This drive provides constant torque below the base speed and constant horsepower characteristics above the base speed.

For adjustable voltage drives the power losses, which make speed adjustment by armature circuit resistance in constant voltage drives inefficient, are avoided. Absence of external resistance in the armature circuit improves the regulation.

Field rheostats with a large number of steps make it possible to start and stop a motor smoothly, such as essential for high-speed elevators and paper-making machines. Also the adjustable voltage system can control a group of motors simultaneously, such as steel mill roll-out tables.

Separate Excited Shunt Adjustable Voltages Drives with Rotating Regulator System

Characteristics: Speed range, 120 to 1 with about 98 percent speed reduction by armature voltage control and 2 to 1 speed increase by field control; speed change, speed variation from no load to full load ± 3 percent; horsepower, unlimited.

The addition of a Rototrol, or rotating regulator, to a conventional adjustable voltage drive gives greater speed range than any of the other commercially available types of drives.

The Rototrol is a d-c generator with multiple fields and a magnetic circuit that has an extremely low residual characteristic. The Rototrol is driven at constant speed by either an induction motor or as part of the m-g set or exciter set of the adjustable voltage drive that it controls.

The basic circuit of the Rototrol and its generated voltage—field ampere-turns curve are shown in Fig. 39. The principal elements of the Rototrol are a self-energizing field (either in series or in parallel with the armature) and two or more separately excited control fields. One of the control fields, called the pattern field, is excited from a constant potential power source. The other control field measures the quantity to be regulated and is called the pilot field. The pattern and pilot fields are generally connected in such a way that their ampere-turns produce magnetic fields that oppose each other. Thus the pilot field measures the quantity to be regulated and compares it with the standard set by the pattern field. Any net difference in these fields causes the Rototrol to develop a corrective action to reduce the difference to zero.

The self-energizing field is designed and tuned by an ordinary resistor adjustment so that the Rototrol resistance line coincides with the air gap line of the no load saturation curve, as shown in Fig. 39. Therefore, the Rototrol operates over the linear part of its saturation curve without the control fields supplying any magnetomotive force for the generation of voltage. Thus the control fields are free and solely for regulating and forcing functions.

The hysteresis effects of the Rototrol magnetic circuit must be minimized for the saturation curve to closely approximate the self-energizing field circuit resistance line. By using special steels, or by using special heat treatment on standard steels, the hysteresis or residual magnetism effect is negligible. A residual voltage value as small as 0.4 percent is common.

In the a-c circuit, Fig. 38 the auto-transformer type of starter for the m-g set keeps line disturbances to a minimum. In this application, the main generator field winding is divided in two equal sections and is connected in a special bridge circuit. The resistances of the main generator and Rototrol field sections are balanced with resistor units in the other two sides of the bridge. Therefore, with zero voltage from the Rototrol armature, there is no difference in potential between the points to which the Rototrol armature is connected. The main generator field sections are

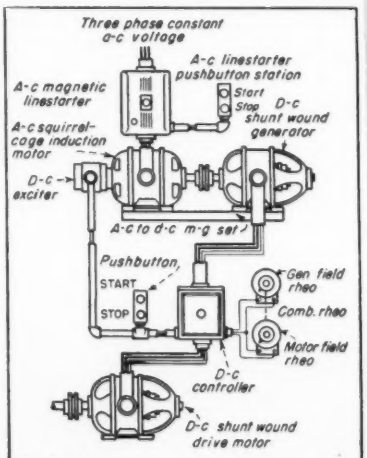


Fig. 37 (A)

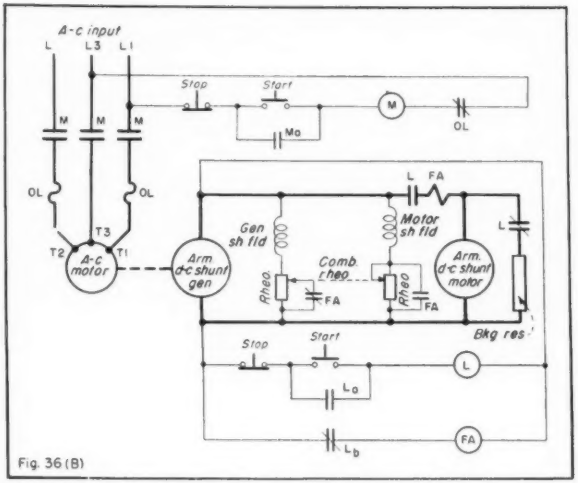


Fig. 36(B)

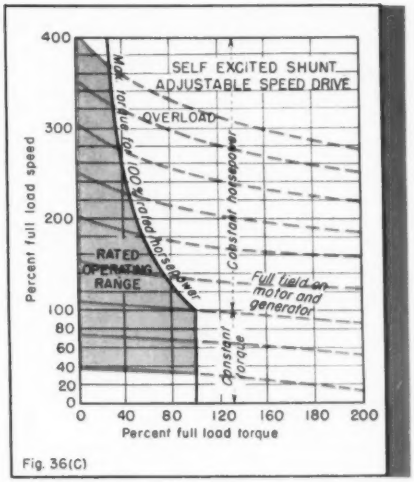


Fig. 36(C)

accumulative and the desired speed of the motor is controlled by the generator field rheostat in the usual manner. The resistance in series with the Rototrol armature tunes the circuit so that the Rototrol operates on the air-gap portion of its saturation curve.

With no load on the motor, resistor marked $R6$ is adjusted so that the fields produced by $RF1$ and $RF2$ are completely neutralized by the shunt pilot field $RF3$. (Magnetic fields $RF1 + RF2 - RF3 = 0$). Under these conditions, the generated output voltage of the Rototrol armature is zero since the net magnetic field is zero.

The Rototrol shunt $RF3$ and series $RF4$ pilot fields are proportioned so that for any load conditions, the net ampere-turns are proportional to the counter emf of the d-c drive motor. With constant field excitation, the speed of a d-c motor is proportional to its counter emf; which, in turn, is equal to the applied voltage minus the motor armature IR drop.

Increase in the motor load causes an increase in the motor armature current, so the ampere-turns of the Rototrol series pilot field $RF4$ increase. The ampere-turns of the series field $RF4$ add to those of the self-energizing fields $RF1$ and $RF2$. Furthermore, a decrease in the main generator output voltage because of the regulation also decreases the ampere-turns produced in the Rototrol shunt pilot field $RF3$. Thus, because of this change in net field excitation, the Rototrol generates a voltage that circulates the current I_b through the Rototrol self-energizing pattern fields, and the main generator fields. This supplements the excitation normally produced by the current I_a from the exciter bus. This additional main generator field excitation increases the generator voltage to a value that restores the d-c drive motor speed to the preset value. Also, the Rototrol series field $RF4$ compensates the circuit for the resistance drop in the lines and the motor armature. The shunt pilot field $RF3$ compensates the circuit for the resistance drop as well as the magnetizing effect that occurs in the main generator armature. All these conditions are integrated by the Rototrol to produce a flat speed-torque

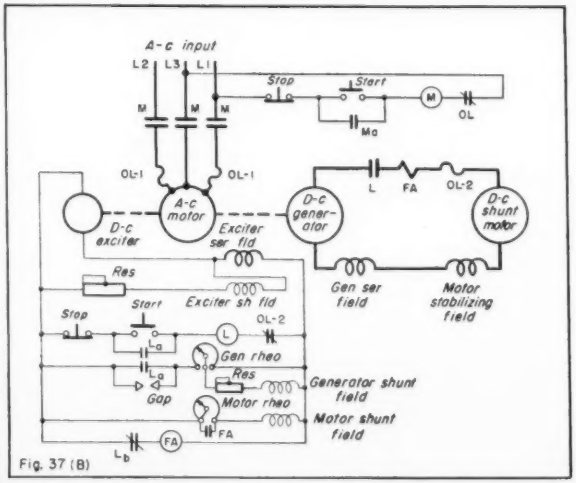


Fig. 37(B)

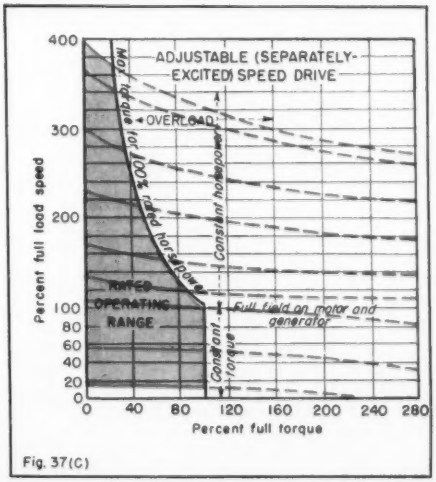
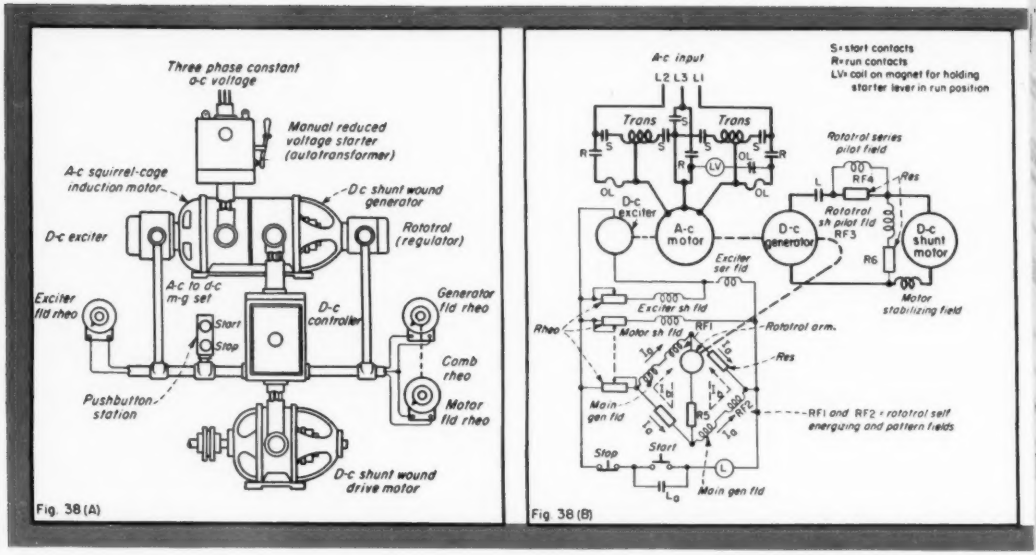


Fig. 37(C)



characteristic. In this circuit, the d-c exciter supplies the normal generator field excitation; the Rototrol supplies only the regulation excitation to maintain the motor speed at a substantially constant value.

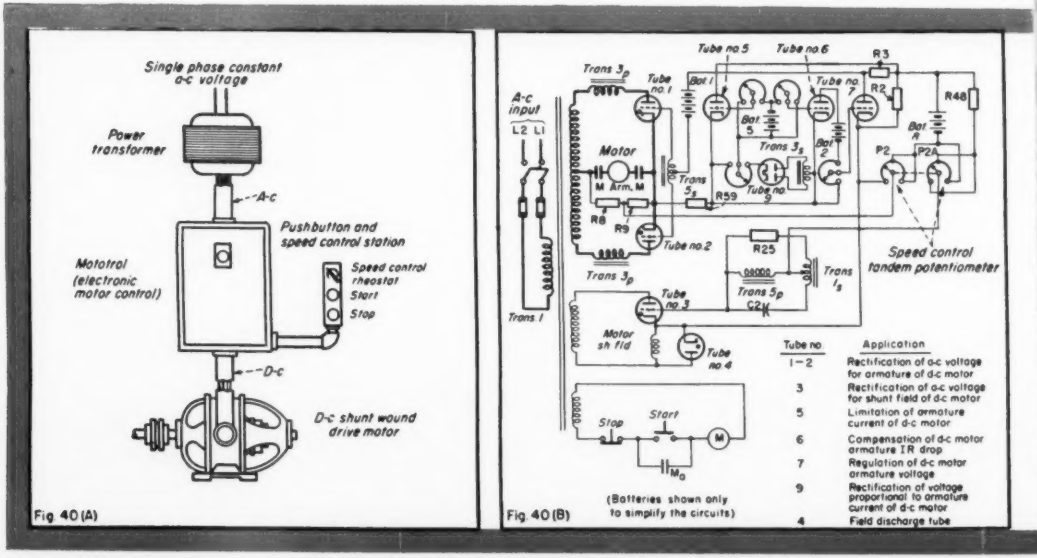
Typical speed torque curves are shown in Fig. 38. The motor has no tendency to stall even at speeds of 1/60 of the base speed. At light loads for this low speed, the voltage required by the drive motor is less than the residual voltage of the main generator. The Rototrol reverses the current in the field of the generator to buck the residual voltage to a value that is exactly sufficient to give the required motor speed. As the motor load increases, the Rototrol voltage polarity reverses again. This particular drive maintains full field on the motor when it is operating below the base speed.

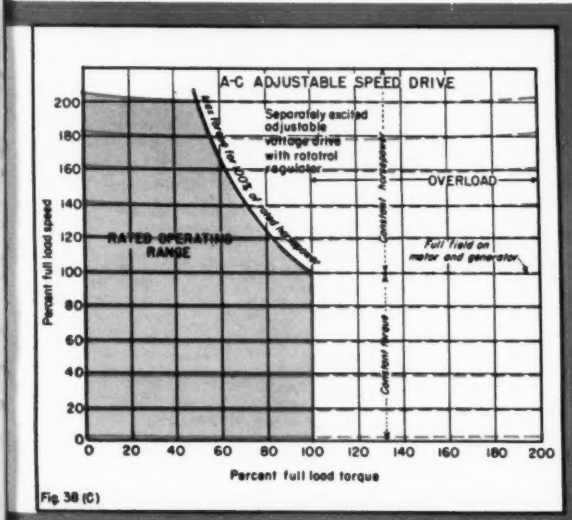
Other basic Rototrol circuits provide more accurate regulation and control for a specific speed, maintain constant torque output, hold the horsepower output constant, give smooth acceleration and deceleration, or potentially provide any drive characteristic that can be measured in units of voltage or current. Typical applications include automatic welding heads, elevators, metal planers, core type paper reels, paper machines, skip hoists, electric shovels and machine tools.

Electronic Drives

Characteristics: Speed range, 40 to 1 with 95 percent speed reduction by armature voltage control and 2 to 1 speed increase by field control; speed change, speed decrease from no load to full load approx. 10 percent at low speed, 1½ percent at base speed, and 8 percent at high speed; horsepower, up to 125.

An electronic power supply can be used in place of the m-g set in a conventional adjustable voltage drive, as shown in Fig. 40. This is especially advantageous where the customary rotating and relatively large control equipment can not be accommodated.




A-C ADJUSTABLE SPEED DRIVE
Separately excited adjustable voltage drive with rototrol regulator
OVERLOAD
RATED OPERATING RANGE
Full field on motor and generator
Constant horsepower
Constant torque
Percent full load speed
Percent full load torque
0 20 40 60 80 100 120 140 160 180 200
Fig. 38 (C)

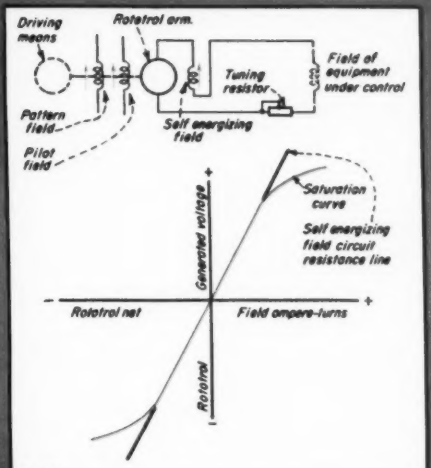


Fig. 39

The electronic drive provides a wide and stable speed range, good speed regulation, and smooth and automatic acceleration of the d-c drive motor.

Grid controlled thyratron tubes serve as controlled rectifiers to supply the field and armature. The larger ratings use ignitron tubes for rectification. They convert either a single phase or polyphase a-c power source to d-c voltage for the motor.

A thyratron or ignitron tube conducts current only when the anode is at a positive potential with respect to the cathode. Once the mercury vapor in the tube ionizes, the conduction can be stopped only when anode to cathode voltage decreases to a low value.

In the Mot-o-trol electronic drive, Fig. 40, an adjustable voltage for the d-c motor armature is obtained by advancing or delaying the point on the a-c anode voltage wage at which the thyratron or ignitron tube conducts current. Fig. 41 shows critical grid voltage characteristics. A small transformer with a center tap, a resistor, and a capacitor form a phase shifting circuit which is used to vary the rectifier output voltage from zero to the rated value. Tube firing or conduction time is accurately controlled for a conducting period of zero to a maximum time of $\frac{1}{2}$ cycle by merely changing the d-c grid voltage component from a negative to a positive value. The principle is shown in Fig. 42. Both the armature and shunt field voltage is controlled in this way.

A typical Mot-o-trol electronic drive comprises an a-c power transformer, an electronic controller, an operator's control station, and a d-c shunt motor. The tandem potentiometer in the control station provides a stepless speed range by armature voltage and field control.

For simplicity, in the schematic diagram Fig. 40, the usual rectifiers in the control circuits are replaced by batteries. Tubes No. 1 and No. 2 provide fullwave rectification of the single phase a-c source. The motor is always started with full field regard-

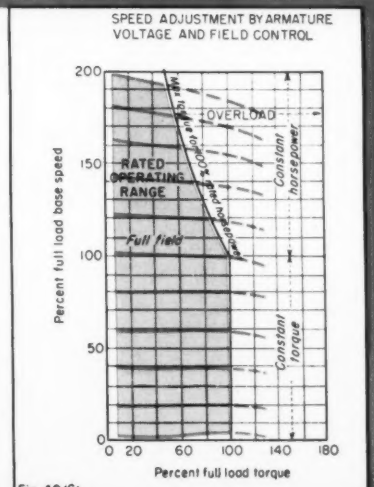
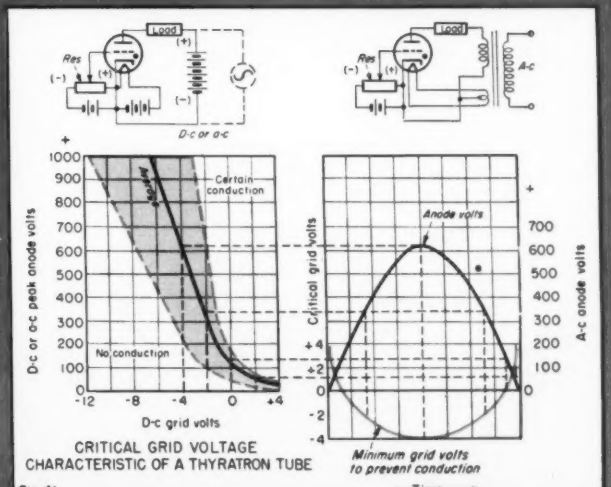


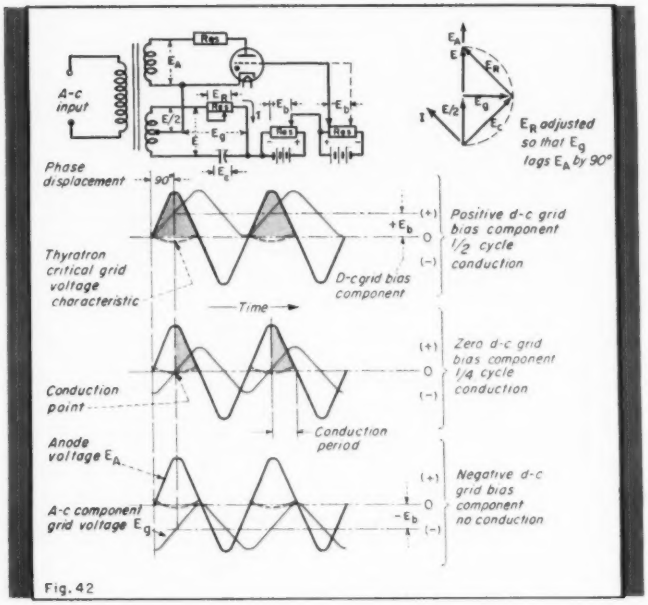
Fig. 40 (C)



CRITICAL GRID VOLTAGE CHARACTERISTIC OF A THYRATRON TUBE
Fig. 41

less of the setting of the speed control potentiometer *P2* and *P2A*. The field weakening control does not become effective until the motor accelerates to its base speed. Transformer No. 3 and tubes No. 5 and No. 9 provide armature current limit control. Fast, smooth, and shockless motor acceleration is automatically provided by these elements that control the d-c voltage component of the grid voltage, which in turn controls the No. 1 and No. 2 thyratron or ignitron tubes. Thus, the voltage output of the armature voltage rectifier tubes is always precisely controlled so that a preset limit on the armature current can never be exceeded. Also, tube No. 6 automatically controls the grid voltage of the tubes No. 1 and No. 2 to compensate for the motor *IR* drop so that an increase in load does not cause the motor speed to decrease. Tube No. 7 corrects the inherently poor voltage regulation of this type of circuit. The coordinated operation of all the control elements provides an output voltage from the rectifier that gives a flat speed —torque characteristic. The shunt field excitation current is rectified by tube No. 3, which is manually controlled by the potentiometer *P2A*. Tube No. 4 provides a discharge circuit for the field current during the time that tube No. 3 is not conducting current.

Typical speed—torque curves are shown. The d-c motors used in this type of drive are usually larger than


A-c input
Phase displacement
90°
Thyratron critical grid voltage characteristic
D-c grid bias component
Time
Conduction point
Conduction period
Anode voltage E_A
A-c component grid voltage E_g
Positive d-c grid bias component 1/2 cycle conduction
Zero d-c grid bias component 1/4 cycle conduction
Negative d-c grid bias component no conduction
E_R adjusted so that E_g lags E_A by 90°
Fig. 42

those of the same horsepower operating at constant speed and from ordinary d-c power sources. This is because the pulsating d-c current from the rectifier circuit increases the heating in the motor. Also, at low speeds, the ventilation of the motor is materially reduced.

Electronic drives are readily adapted for inching, reversing, or dynamic braking. They are not suitable for regenerative braking on overhauling loads. Except for the drive motor, the electrical components are vibrationless and provide a more compact unit than an equally rated m-g set.

A-C Motor Drives—A-C Power Source and Conversion Equipment

The speed of an a-c motor can be adjusted by changing the frequency of the applied voltage. The main disadvantage to this type of speed control is that the adjustable frequency system requires considerable conversion equipment.

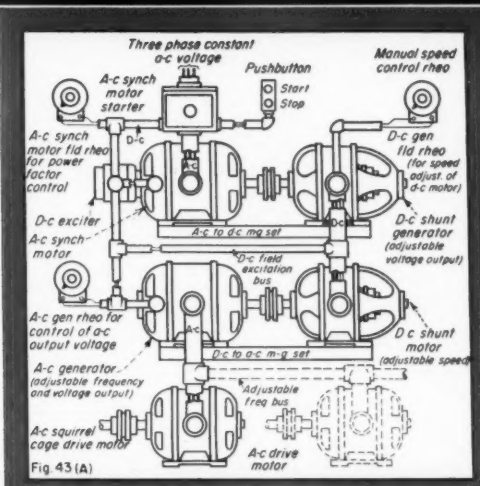
Adjustable Frequency Drives—M-G Sets

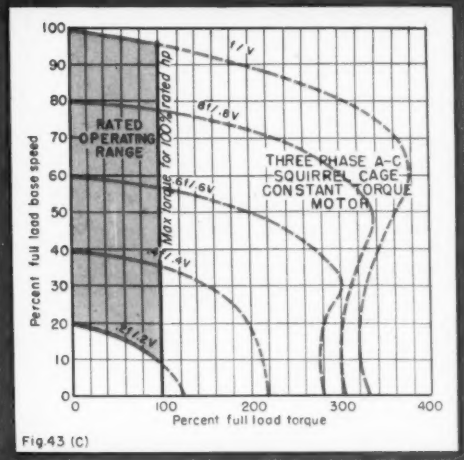
Characteristics: Speed range, 5 to 1 or 6 to 1 for typical drives; 80 or 85% speed reduction by frequency control; speed change, speed decrease from no load to full load—without d-c to a-c m-g set drive motor speed compensation approx 80 percent at low speed and 15 percent at base speed; with d-c to a-c m-g set drive motor speed compensation 50 percent at low speed and 5 percent at base speed; horsepower, unlimited.

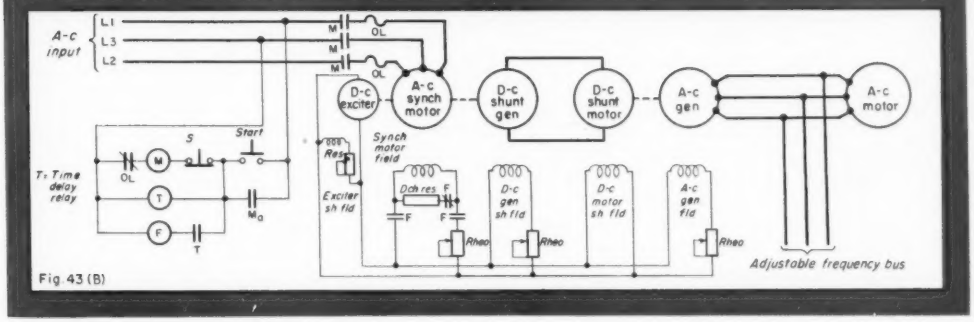
A typical adjustable frequency system is shown in Fig. 43. It consists of an a-c synchronous drive motor and a d-c shunt wound generator (a-c to d-c adjustable voltage d-c m-g set), a d-c drive motor and an a-c generator (d-c to a-c adjustable voltage and frequency a-c m-g set), and an a-c squirrel-cage drive motor.

Usually, such a drive is practical and economical only when a number of drive motors are to be simultaneously controlled and operated at exactly the same speed, such as for steel mill roll-out tables.

An undesirable characteristic of this drive is that the speed regulation of the drive motor is affected by the summation of the regulation of all the machines in the system. This poor regulation characteristic can be minimized to almost that of the squirrel-cage drive motor by using: (1) A synchronous drive motor for the a-c to d-c m-g set; and (2) a Rototrol regulator to maintain the speed of the d-c drive motor of the d-c to a-c m-g set at a reasonably constant value for all conditions of load. Also, a synchronous motor can supply power factor correction. As shown in the schematic diagram, pressing the "Start" button energizes the coils *M*, and *T;* the *M* contacts close and apply voltage to the synchronous motor. During the starting period, the synchronous motor d-c field winding is shunted by a resistor that is in series with a normally closed contact *F*. After a definite time period and the synchronous


Three phase constant d-c voltage
Manual speed control rheo
A-c synch motor starter
Pushbutton
Start
Stop
A-c synch motor fld rheo for power factor control
D-c gen fld rheo (for speed adjust. of d-c motor)
D-c exciter
A-c synch motor
A-c to d-c m-g set
D-c shunt generator (adjustable voltage output)
D-c field excitation bus
A-c gen rheo for control of a-c output voltage
D-c to a-c m-g set
D-c shunt motor (adjustable speed)
A-c generator (adjustable frequency and voltage output)
Adjustable freq bus
A-c squirrel cage drive motor
A-c drive motor
Fig 43 (A)


Percent full load base speed
Percent full load torque
RATED OPERATING RANGE
THREE PHASE A-C SQUIRREL CAGE CONSTANT TORQUE MOTOR
Motor speed curves
Fig 43 (C)



motor has accelerated to a speed high enough for synchronization, the relay contact T closes and energizes the coil F of the field contactor. This opens the protective shunting resistor circuit, applies d-c to the field, and the synchronous motor pulls into step.

The control can be arranged so that the actual drive motors are always started at the lowest speed. Speed control and adjustment can be readily obtained by operating only the d-c generator shunt field rheostat.

As the inductive reactance of an a-c motor varies directly with the frequency, the applied voltage and frequency must always be in approximately the same ratio of volts per cycle for any speed. This is essential for the motor to develop the necessary torque and to limit the current to a safe value. ($X_L = 2\pi fL$ where $X_L =$ the inductive reactance, $\pi = 3.14$, $f =$ the frequency, and $L =$ inductance of winding.) Winding resistance factor predominates at lower frequencies.

These curves are based upon the regulation only of the a-c squirrel-cage drive motor. Unless the a-c to d-c m-g set drive motor operates at constant speed for any setting, the actual regulation of the drive will be greater than that shown by the curve. Any number of intermediate speeds can be obtained. With this type of control, a load can be started smoothly as the starting torque steadily increases as the applied voltage and frequency to the drive motor are increased.

When it is necessary that the drive motors operate at absolutely constant speed, synchronous motors can be used.

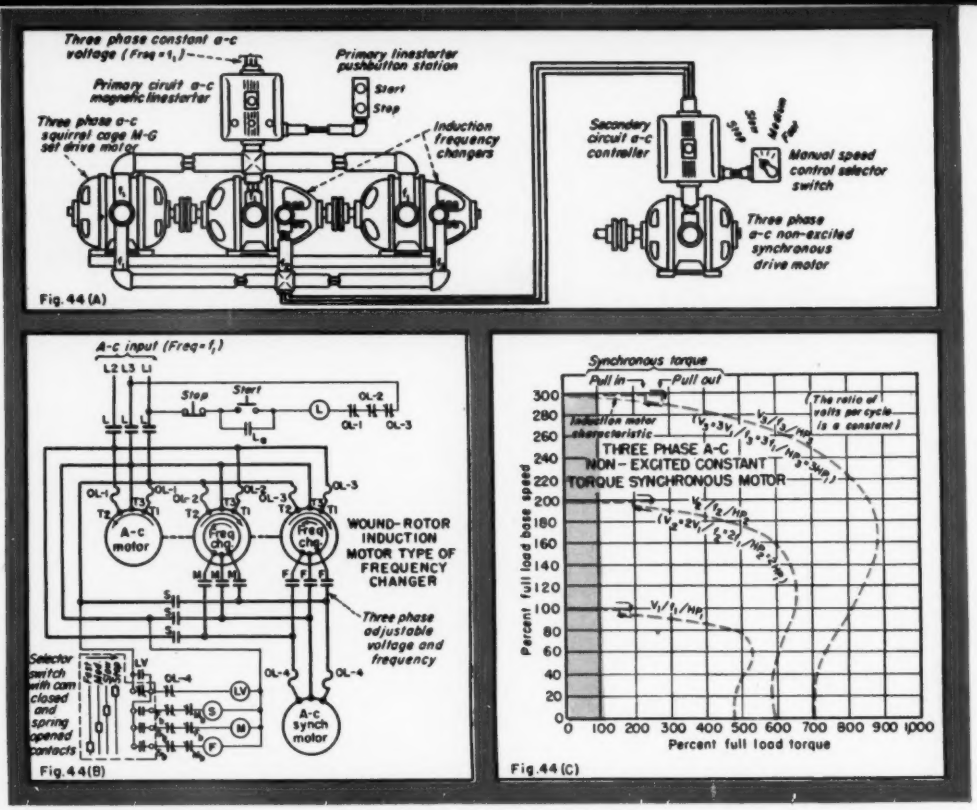
Adjustable Frequency Drives—Induction Generator Sets

Characteristics: Speed range, 2 to 1 or 3 to 1 for typical drives (2 to 1 or 3 to 1 speed increase by frequency control); speed change, speed decrease from no load to full load: With induction motor driven set and squirrel-cage drive motor, 10 percent at base speed and 3 percent at high speed; with synchronous motor driven set and squirrel-cage drive motor, 5 percent at base speed and 1½ percent at high speed; with synchronous motor driven set and synchronous drive motor, 0 percent at base and high speed; horsepower, up to 60 for induction motor driven sets; up to 100 for synchronous motor driven sets.

Induction frequency changers are used extensively for supplying high frequency drive motors in the woodworking and rayon industries that require relatively high speeds of the type shown in Fig. 4. The induction type of generator is ideal for applications where sturdiness, simplicity, reliability, low maintenance, and good regulation are important. Ordinary systems convert from 25, 50, and 60 cycles up to 175 or 180 cycles. Induction generators are not used to obtain frequencies lower than the supply frequency because the lower than base speeds can be readily obtained with multi-speed motors in a more economical manner.

An induction generator is a wound-rotor induction motor the rotor of which is driven opposite to the direction of its rotating magnetic field. When an induction motor primary field is energized with a polyphase voltage, a rotating magnetic field is produced. The speed of the field rotation depends upon the frequency and the number of poles. This primary circuit revolving field induces a voltage in the rotor or secondary winding of the motor. This action is similar to that in a two winding transformer.

A portion of the power output from an induction generator is supplied by



direct transformer action between the primary winding and the rotor winding. This power transfer varies with the ratio of input to output frequency. For example, on 60 to 180 cycle conversion, one-third of the power output is supplied by direct transformer action. The set drive motor must be large enough to supply the other two-thirds of the output plus a portion of the induction generator losses.

An m-g set, Fig. 44, can be constructed from standard machines. With an induction motor and two wound-rotor motors with a different number of poles, two frequencies higher than that of the line supply can be obtained. A standard a-c linestarter with additional overload protection for the induction generators can be used for the primary control. For the secondary control, an a-c controller and a selector switch can be used to operate the drive motor at the desired speed.

In the schematic diagram, depressing the "Start" button starts the m-g set drive motor and energizes the primary windings of the induction generators. The manually operated cam selector switch is set for the desired speed. The speed also could have been selected by a completely magnetically operated controller, if wanted. This control scheme provides low-voltage protection. The slow *S*, medium *M*, and fast *F* speed contactors are interlocked electrically to prevent the coil on one contactor from being energized unless the other two contactors are de-energized.

The squirrel-cage type of induction motor is frequently operated on the power output of an induction generator set. But to illustrate how an absolutely constant output speed can be obtained, the speed-torque characteristics of a non-excited synchronous motor are shown. These curves are based upon a synchronous m-g set so there is zero percent speed decrease in the set driving motor from no load to full load.

A non-excited synchronous motor is similar to an ordinary squirrel-cage induction motor except for slots that are milled in the rotor. This alteration changes the reluctance of and the distribution of the magnetic flux in the rotor iron. The flux lines are concentrated in certain armature regions similar to machines with salient poles. The starting torques shown for this type of motor are greater than those for a three phase squirrel-cage motor of the same full load rating; the rated output of a given non-excited synchronous motor is only about one-third that of the standard rating of the motor from which it was made.

This particular type of drive motor pulls into step at approximately 150 to 225 percent of full load torque and then operates at a constant speed. The pull out torque is higher than the pull in value, as shown in the curves. The pull in torques for the 100 and 200 percent base speeds can be increased to that at the 300 percent speed by slightly increasing the applied voltage.

For just one or two speeds and where intermediate operating speeds are not required, the induction frequency changer set is more economical than the adjustable frequency set.

Graphic Comparison of Electrical Drives

A graphic summary and comparison of the speed control characteristics of different electrical drives are shown in Table I. In selecting the most satisfactory drive for a given application, the cost, speed range, speed in rpm, change in speed from no load to full load, and the horsepower rating commercially available are factors that should be taken into consideration.

Belleville Spring Design Charts—I

LESLIE W. JONES
Corning Glass Works

IN CALCULATING the height and thickness of Belleville springs to suit conditions of given outside diameter, inside diameter, applied load, and deflection, the usual method is to use load and stress formulas that contain constants. These constants are evaluated by graphs, such as shown in Fig. 1, for different ratios of outside diameter to inside diameter. In the load and stress formulas that use the constants evaluated in Fig. 1,

P = applied axial load on disk, lb
S = maximum stress at outer edge of disk, psi
a = outside radius of disk, in.
t = thickness of disk, in.
h = free height of disk, in.
d = axial deflection of disk, in.
E = modulus of elasticity of material in disk, psi
= 30,000,000 for steel
μ = Poissons ratio = 0.3 for steel
M, C_1, and C_2 are constants taken from Fig. 1

The load formula is

$$P = \frac{E\,d}{(1-\mu^2)\,M\,a^2} \times \left[(h-d)\left(h-\frac{d}{2}\right)t + t^3\right] \qquad (1)$$

The stress formula is

$$S = \frac{E\,d}{(1-\mu^2)\,M\,a^2} \times \left[C_1\left(h-\frac{d}{2}\right) + C_2 t\right] \qquad (2)$$

These formulas and Fig. 1 are taken from "The Uniform-Section Disk Spring" by J. O. Almen and A. Lazlo, see A.S.M.E. *Transactions*, May 1936 page 305.

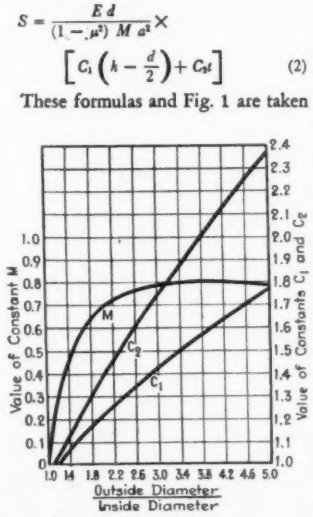


Fig. 1—Load and stress constants for calculating disk springs.

To simplify the tedious procedure required to obtain solutions with these formulas, a series of nomographic charts for plain carbon steel springs has been prepared based on the data of Fig. 1 and Eqs (1) and (2). The series includes charts for springs having different percent rates of pressure rise and pressure drop, and for springs in which a negative pressure is produced over a range of disk deflection. Charts for springs having zero, ten, and twenty percent rate pressure rise are presented on pages 163, 165, 167, respectively. Other charts will follow in subsequent numbers of PRODUCT ENGINEERING. With the help of a straight edge, it is possible to read values directly from the charts with no additional computation.

Each chart has four parts: (1) Pressure scale and pressure-deflection curve, (2) inside and outside diameter relation scales, (3) dish and thickness scales, and (4) maximum stress scale.

The pressure scale indicates the maximum pressure or any percentage thereof. When the disk is deflected to a flat, the pressure falls halfway between the maximum and minimum pressure peaks; this condition is also true for negative pressure springs. For convenience the pressure curve is laid out on a uniform scale and is projected to the left to the logarithmic scale from which the pressure scale is determined. The relation of the turning scale to the pressure scale is indicated on the chart.

The diameter scales indicate values of outside diameter and inside diameter. In using the chart, as indicated by the arrows, it is necessary to pass from the value of the outside diameter through the inside diameter directly across the stress and pressure correction scale, then return as indicated through the value of the outside diameter to the right hand turning scale. One path is for the stress; the other for the pressure. As the ratio of the outside diameter to the inside diameter increases beyond 2.2 to 1, the stress correction chart cuts back on itself.

The dish and thickness scales, midway between the turning scales, indicate the amount of dish and thickness necessary for the desired pressure.

The maximum stress scale, in the lower right hand corner, is in units of 10,000 psi. The line that indicates the maximum stress is parallel to the line that connects the points of dish and thickness to the turning scale resultant from the stress correction scale.

Secant 1 connects the point of maximum pressure on pressure scale with the 100 percent point on the left hand scale, and is extended to turning scale *A*. Deflections in terms of free disk height at any percent of the maximum pressure are read by the aid of the horizontal percent lines and the ordinates of the deflection-pressure curve.

Secant 2 connects points of outside diameter and inside diameter and is extended to cut the left hand side of pressure and stress correction scales.

Secant 3 connects the ray coming out of the stress correction scale, as determined by secant 2, and the point of outside diameter, and is extended to intercept turning scale *B*.

Secant 4 connects the ray coming out of the pressure correction scale, as determined by secant 2, and the point of outside diameter, and is extended to intercept turning scale *B*.

Secant 5 connects the intersection of secant 1 with turning scale *A* and the intersection of secant 4 with turning scale *B*. The intersection of secant 5 with the *h* and *t* scales gives values of dish and thickness.

Secant 6 connects the intersection of secant 3 with turning scale *B* and values of dish and thickness on the *h* and *t* scales.

Secant 7 is drawn parallele to secant 6 and gives maximum stress at the outside edge of disk.

For springs larger than those shown on the charts, multiply the *I D*, *O D*, *h*, and *t* scales by 10 and the pressure scale by 100.

For springs smaller than those shown on the charts, divide the *I D*, *O D*, *h*, and *t* scales by 10 and the pressure scale by 100.

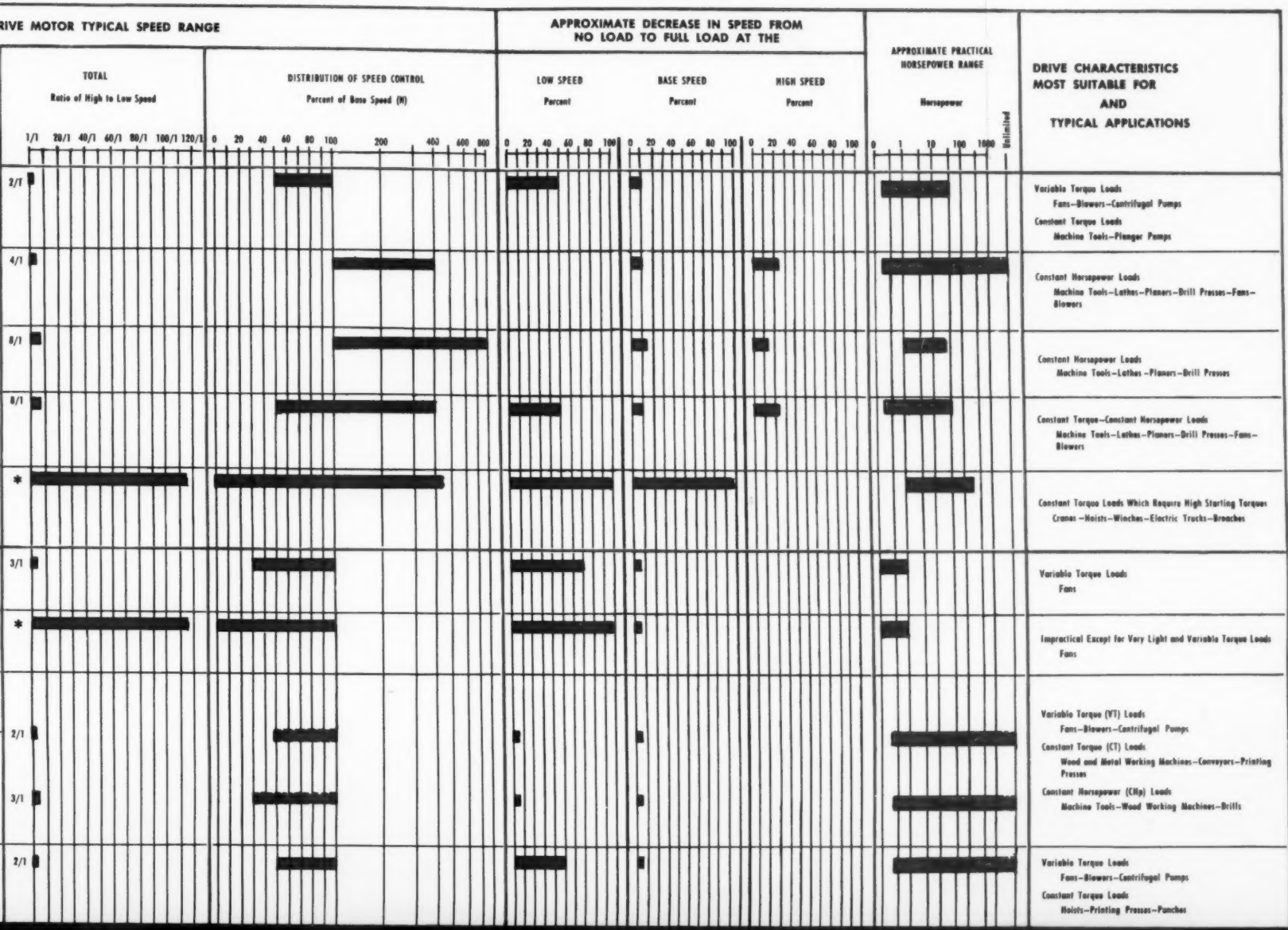
For very light springs, divide the *h* and *t* scales by 10; the pressure scale by 10,000; and the stress scale by 100.

By using 200,000 psi as a safe maximum stress, these charts can be used as a criterion for designing and developing plain carbon steel Belleville springs. (*continued on page 163*)

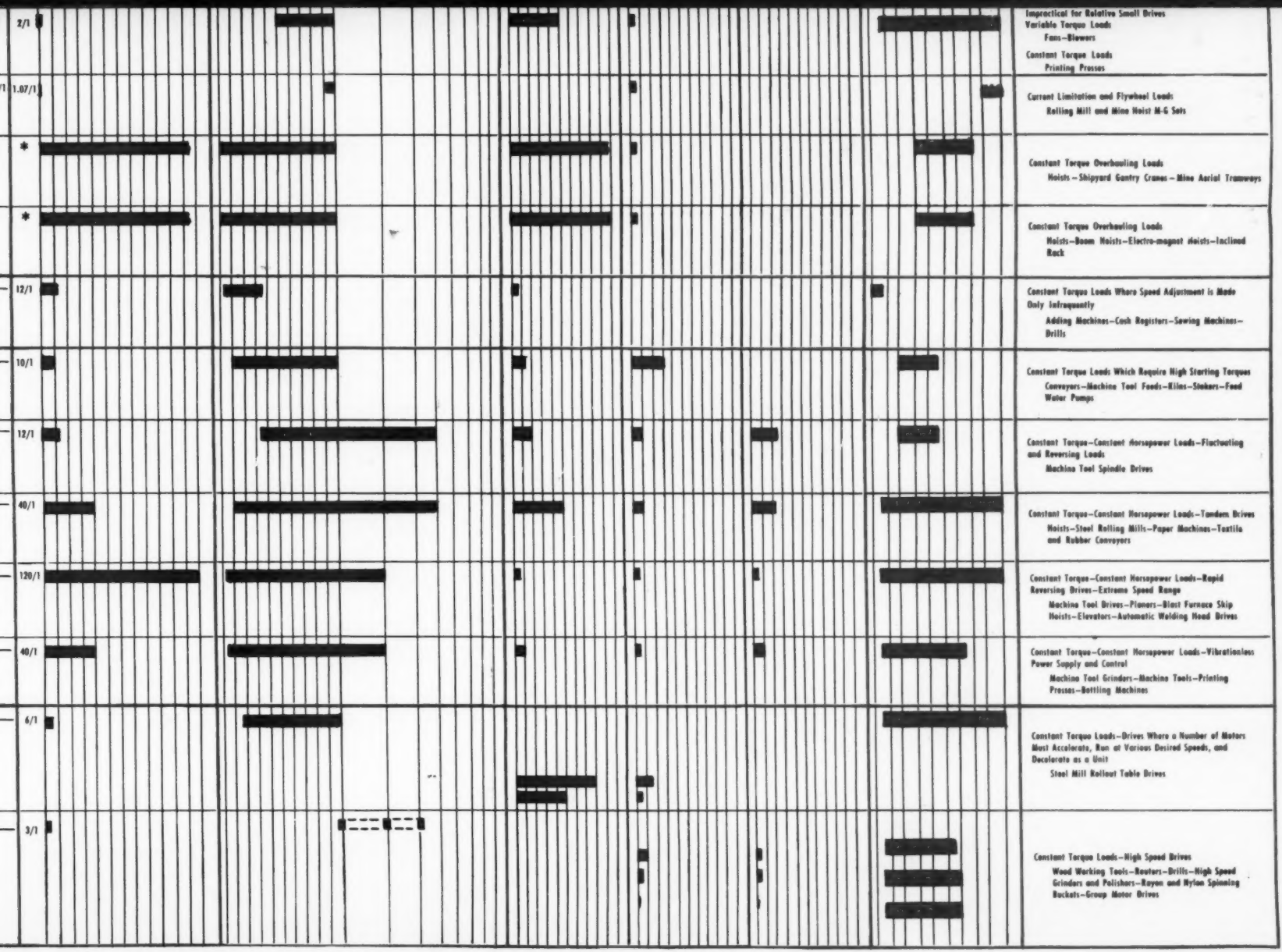
TABLE I- SUMMARY AND COMPARISON OF SPEED CONTROL

POWER SUPPLY	MOTOR	TYPE OF DRIVE CONTROL AND TYPE OF MOTOR AND TYPE OF CONTROLLER	FIG. NUMBER FOR TYPICAL: Equipment Required	Circuit Diagram	Speed-Torque Curves	RELATIVE ORDER OF: Simplicity	SPEED (H = High, B = Base, L = Low)	COST ● In percent for a 10 Hp Drive with Approximate Maximum Speed of 1,800 RPM (0 200 400 600 800 1,000 1,200 1,400 1,600 1,800)	DEGREE OF SPEED ADJUSTMENT: Practically no Adjustment; Very Coarse; Coarse; Fairly Good; Good; Very Good; Excellent; Superb	OBTAINED BY CONTROL OF: D-C: ARMATURE CIRCUIT: Resistance	D-C: ARMATURE CIRCUIT: Voltage	D-C: Field Circuit Excitation	A-C: PRIMARY CIRCUIT: Resistance	A-C: PRIMARY CIRCUIT: Impedance	A-C: PRIMARY CIRCUIT: Voltage	A-C: PRIMARY CIRCUIT: D-C Excitation	A-C: PRIMARY CIRCUIT: Frequency	A-C: PRIMARY CIRCUIT: Pole Grouping	A-C: Secondary Circuit Resistance	DRIVE MOTOR TYP: TOTA Ratio of High (1/1 20/1 40/1)
D-C	D-C	Armature Resistance Control	10(A)	10(B)	10(C)	3	B = 1,750 L = 875			2/1	—	—	—	—	—	—	—	—	—	—	2/T
		D-C Shunt Wound Motor																				
		Manually Operated Rheostat																				
		Manually Operated Drum																				
		Field Excitation Control	12(A)	12(B)	12(C)	5	H = 1,800 B = 450			—	—	4/1	—	—	—	—	—	—	—	4/1
		D-C Shunt Wound Motor																				
		Manually Operated Rheostat																				
		Magnetic Starter + Field Rheostat																				
		Special Field Excitation Control	13(A)	13(B)	13(C)	6	H = 2,000 B = 750			—	—	8/1	—	—	—	—	—	—	—	8/1
		D-C Special Shunt Wound Motor																				
		Magnetic Starter + Field Rheostats																				
		Armature Resistance and Field Excitation Control	14(A)	14(B)	14(C)	9	H = 1,800 B = 450 L = 225			2/1	—	4/1	—	—	—	—	—	—	—	8/1
		D-C Shunt Wound Motor																				
		Manually Operated Rheostat																				
		Manual Drum + Field Rheostat																				
		Armature Resistance Control	15(A)	15(B)	15(C)	10	B = 1,750 L = *			*	—	—	—	—	—	—	—	—	—	—	*
		D-C Series Wound Motor (Int. Rating)																				
		Manually Operated Drum																				
		Magnetic Controller + Master Switch																				
A-C	A-C	Primary Voltage Control	20(A)	20(B)	20(C)	2	◆			—	—	—	—	—	3/1	—	—	—	—	3/1
		A-C Single Phase Capacitor Motor																				
		Autotransformer + Selector Switch																				
		Primary Resistance Control	22(A)	22(B)	22(C)	8	◆			—	—	—	*	—	—	—	—	—	—	*
		A-C 3 Phase Squirrel-Cage Motor																				
		Resistor + Drum Controller																				
		Pole Grouping Control	23(A)	23(B)	23(C)	4																
		A-C 3 Phase Squirrel-cage Multi-speed Motor																				
		Manually Operated Drum					B = 1,740 L = 870															
		2 Speed–1 Winding VT						100		—	—	—	—	—	—	—	—	—	2/1	—	2/1
		2 Speed–1 Winding CT						100														
		2 Speed–1 Winding CNp																				
		Magnetically Operated Controller																				
		4 Speed–2 Winding VT					B = 1,740 3rd = 1,155															
		4 Speed–2 Winding CT					2nd = 870			—	—	—	—	—	—	—	—	—	3/1	—	3/1
		4 Speed–2 Winding CNp					L = 580															
		Secondary Resistance Control	25(A)	25(B)	25(C)	7	B = 1,745 L = 875			—	—	—	—	—	—	—	—	—	—	2/1	2/1
		A-C 3 Phase Wound-Rotor Motor																				
		Primary Magnetic Starter + Secondary Manually Operated Rheostat																				

ONTROL CHARACTERISTICS FOR ELECTRICAL DRIVES

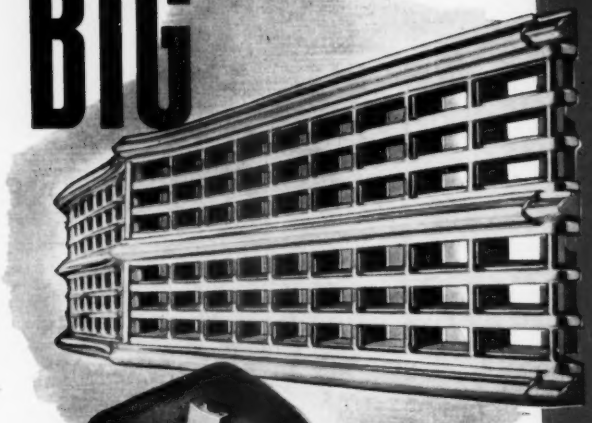


| | | |


2/1
Impractical for Relative Small Drives
Variable Torque Loads
Fans—Blowers
Constant Torque Loads
Printing Presses
1.07/1
Current Limitation and Flywheel Loads
Rolling Mill and Mine Hoist M-G Sets
*
Constant Torque Overhauling Loads
Hoists—Shipyard Gantry Cranes—Mine Aerial Tramways
*
Constant Torque Overhauling Loads
Hoists—Boom Hoists—Electro-magnet Hoists—Inclined Rack
12/1
Constant Torque Loads Where Speed Adjustment is Made Only Infrequently
Adding Machines—Cash Registers—Sewing Machines—Drills
10/1
Constant Torque Loads Which Require High Starting Torques
Conveyors—Machine Tool Feeds—Kilns—Stokers—Feed Water Pumps
12/1
Constant Torque—Constant Horsepower Loads—Fluctuating and Reversing Loads
Machine Tool Spindle Drives
40/1
Constant Torque—Constant Horsepower Loads—Tandem Drives
Hoists—Steel Rolling Mills—Paper Machines—Textile and Rubber Conveyors
120/1
Constant Torque—Constant Horsepower Loads—Rapid Reversing Drives—Extreme Speed Range
Machine Tool Drives—Planers—Blast Furnace Skip Hoists—Elevators—Automatic Welding Head Drives
40/1
Constant Torque—Constant Horsepower Loads—Vibrationless Power Supply and Control
Machine Tool Grinders—Machine Tools—Printing Presses—Bottling Machines
6/1
Constant Torque Loads—Drives Where a Number of Motors Must Accelerate, Run at Various Desired Speeds, and Decelerate as a Unit
Steel Mill Rollout Table Drives
3/1
Constant Torque Loads—High Speed Drives
Wood Working Tools—Routers—Drills—High Speed Grinders and Polishers—Rayon and Nylon Spinning Buckets—Group Motor Drives

the load). ★Practical only for a group of drive motors. ▲Not practical below base speed. (Use multi-speed motors below base speed).

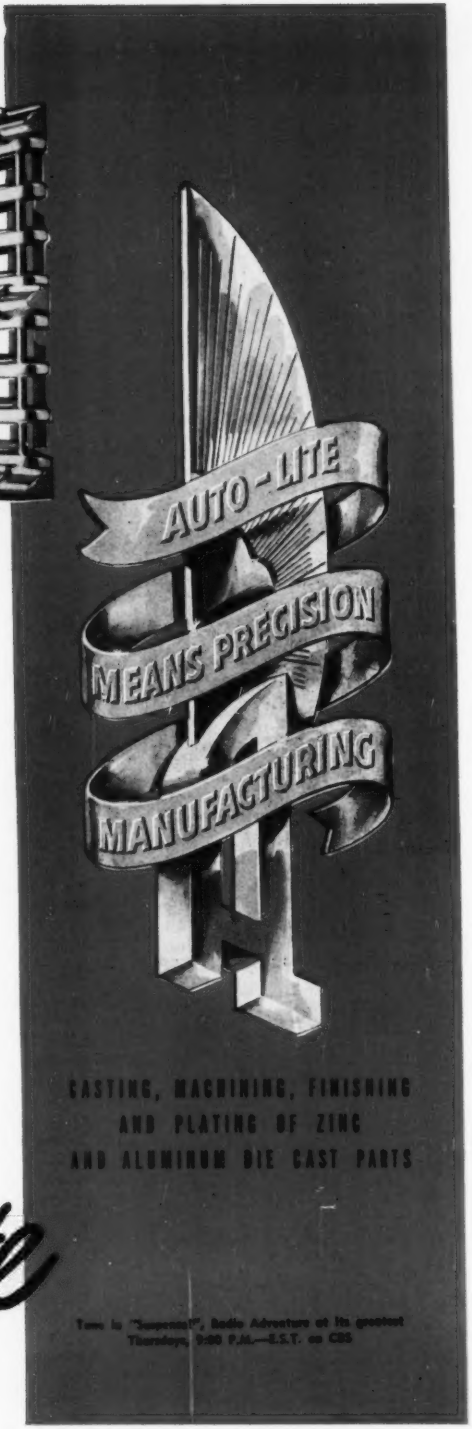
BIG



... and small

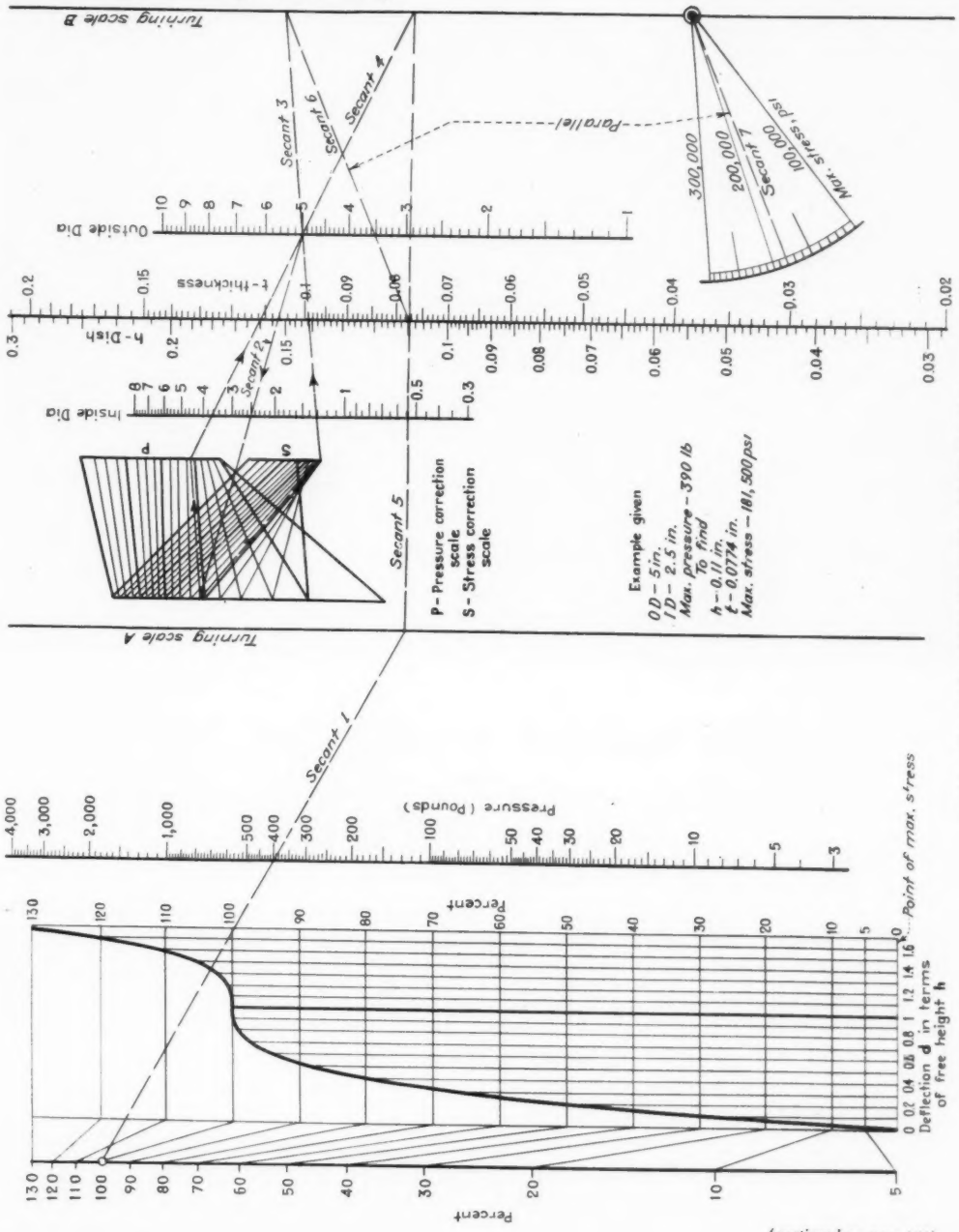
● From small precision-made parts to massive radiator grilles in glittering chrome, Auto-Lite's die casting research and experience is helping industry develop a wide variety of new products. Through its "Controlled Metals" inspection processes, plus the finest production equipment and methods, Auto-Lite is able to assure manufacturers beauty, strength and accuracy on every type of job.

THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division, Woodstock, Illinois
600 S. Michigan Avenue · Chicago 5, Illinois
723 New Center Building · Detroit 2, Michigan

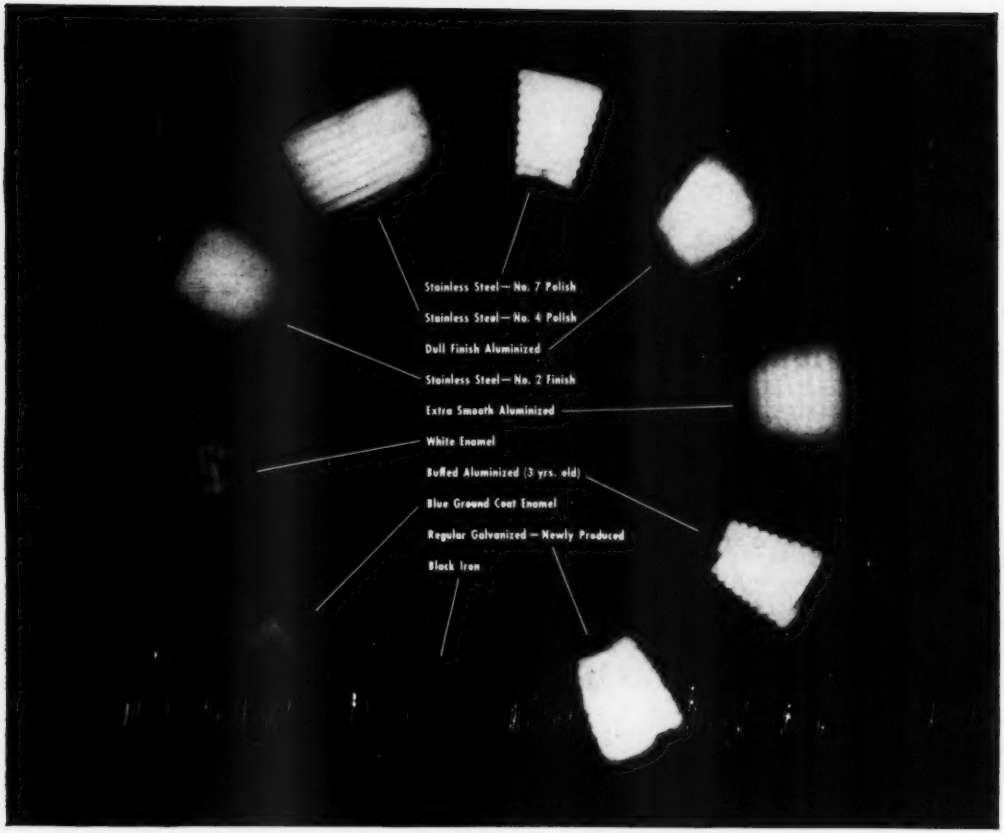


DIE CASTING *by* *Auto-Lite*

Belleville Spring Design (continued)



(continued on page 165)



This Special Steel Gives 700° F. The bounce-off

If the efficiency of your product is measured by its ability to reflect heat, you'll be interested in this unusual photo.

Taken on special film in a four-hour exposure, the picture shows the heat reflections of an electric heating element from ARMCO ALUMINIZED Steel and other materials. Only highly polished ARMCO Stainless Steel made a better showing.

Samples were exposed to infra-red rays in total darkness at 700° F. Intensities of the reflections are a direct measure of the heat reflective properties of the various metals.

Besides reflecting heat, ARMCO ALUMINIZED resists discoloration up to 900° F. And it has excellent corrosion resistance.

Armco-created ALUMINIZED Steel is sheet steel with a tightly adherent hot-dipped aluminum coating on both sides. It gives your products the surface characteristics of the aluminum coating and the strength of steel. Moreover, this union of metals produces many important advantages which *neither steel nor aluminum alone can give you.* Armco Steel Corporation, 507 Curtis Street, Middletown, Ohio.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION

ARMCO ALUMINIZED STEEL

Belleville Spring Design (continued)

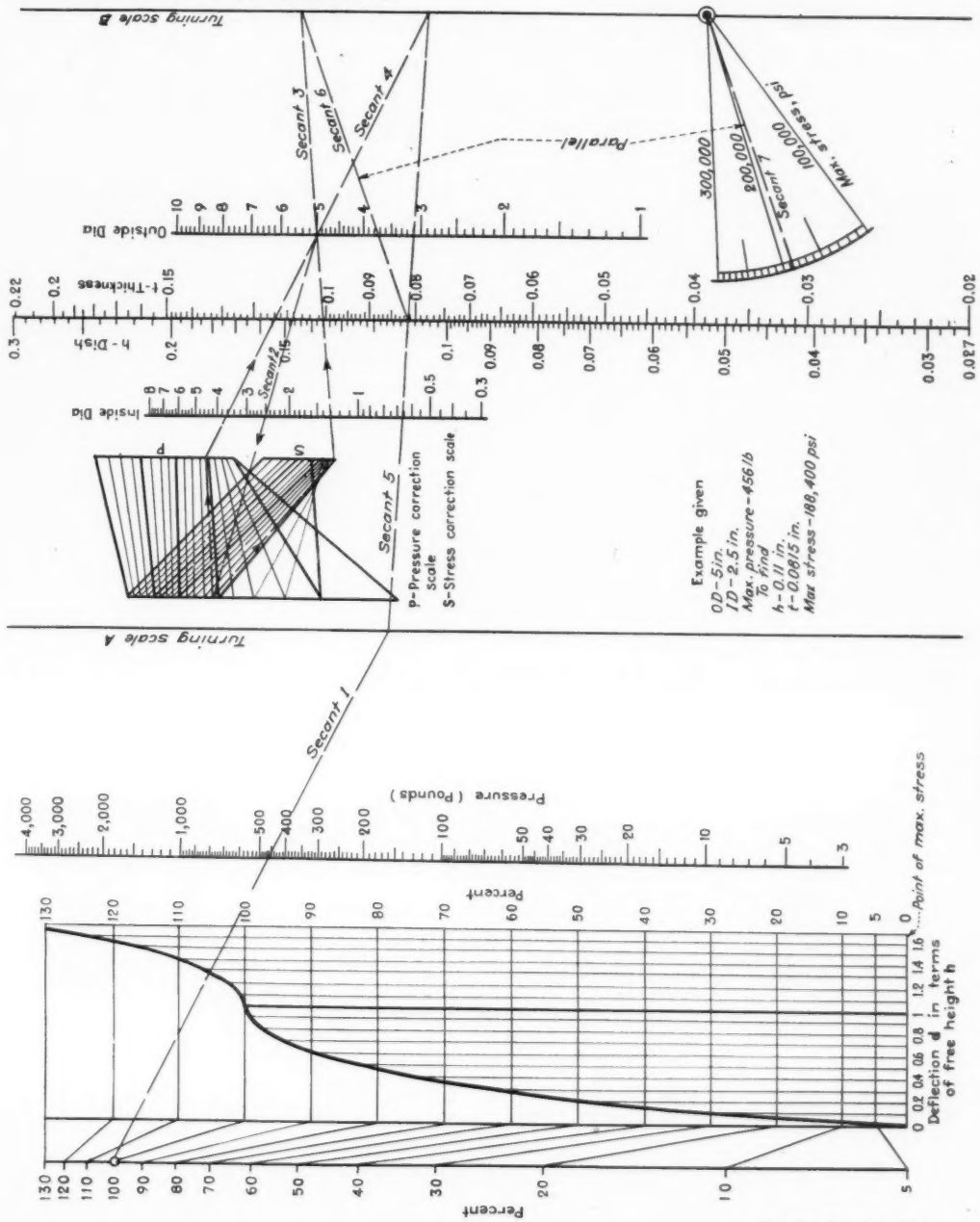
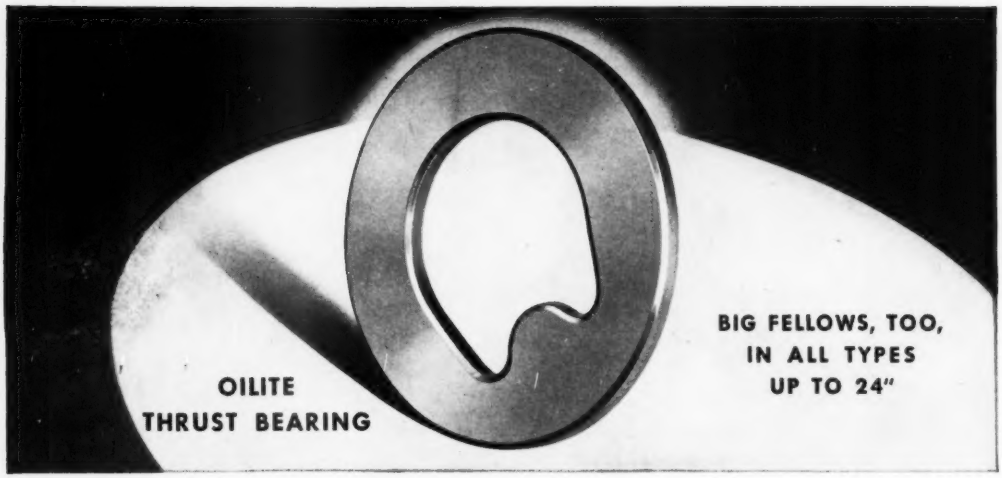


CHART FOR TEN PERCENT RATE PRESSURE RISE

(continued on page 167)

OILITE

OIL CUSHION — HEAVY DUTY BEARINGS



Metered, Self-Lubrication, No Waste

OILITE—The HEAVY DUTY OIL CUSHION BEARING with Reserve Capacity.
OILITE operates under the principles of hydraulics.
OILITE is a precision product and permits lower bearing clearances.

PLAIN SLEEVE

OTHER ADVANTAGES INCLUDE:

- Every bearing is an engineered product.
- Oilite bearings can be assembled and the bore finished simultaneously—reducing costs.
- Ferrous and non-ferrous, oil cushion bearings.
- No blow holes or other flaws.
- Production tools on hand for over 18,000 different types and sizes.
- Large research and engineering staff.
- Complete engineering service.
- Greater plant facilities.
- Over twenty (20) years of powder metal know-how.
- Representation in every state and Canada.
- Oilite bearings are not expensive.

FLANGE

Send your blueprints to Amplex Field Engineer or the Home Office. Address Dept. C.

AMPLEX MANUFACTURING CO. DETROIT, 31 MICHIGAN

Division of Chrysler Corporation

FIELD ENGINEERS AND SUPPLY DEPOTS IN PRINCIPAL CITIES

Belleville Spring Design (continued)

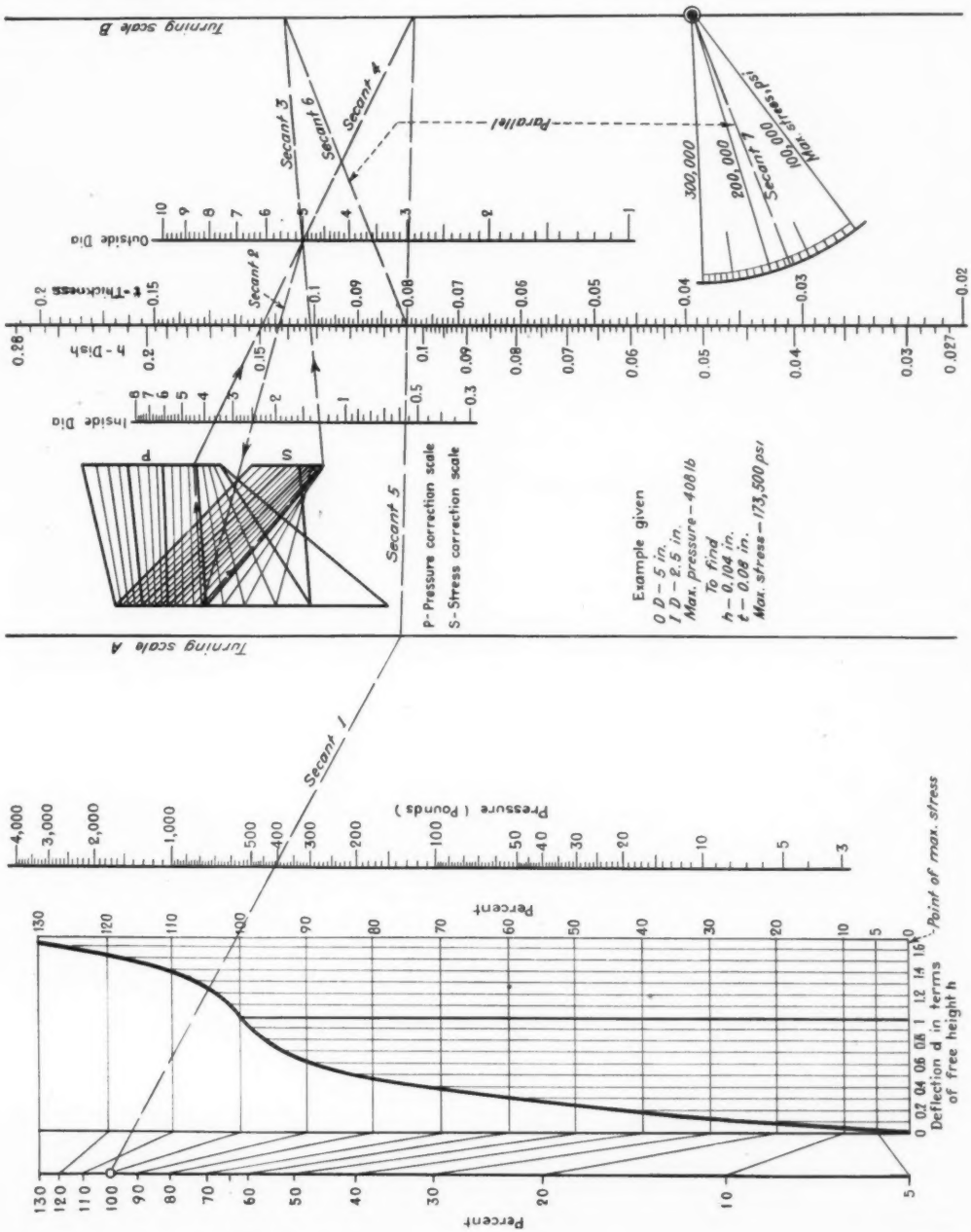


CHART FOR TWENTY PERCENT RATE PRESSURE RISE

more HOME APPLIANCES PER TON—

more DURABILITY PER APPLIANCE WITH

N-A-X HIGH-TENSILE STEEL

N-A-X HIGH-TENSILE saves three ways when used in the manufacture of home appliances.

Because of its inherent high strength and toughness, up to 33% more units per ton can be produced than with ordinary carbon sheet steel.

Because sections can be made lighter without sacrifice of strength or durability, handling weight can be reduced, packaging and shipping costs lowered.

N-A-X HIGH-TENSILE provides a smoother surface texture when drawn, permitting substantial savings on finishing.

Why not investigate the possibilities of N-A-X HIGH-TENSILE for your products?

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N·A·X
HIGH-TENSILE STEEL

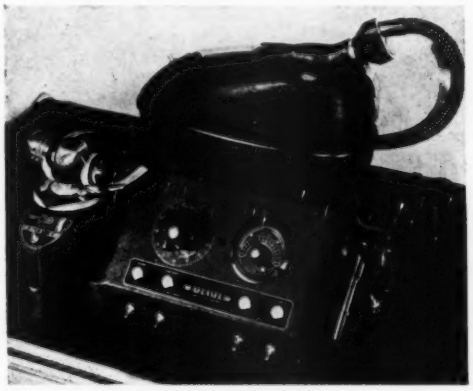
COPYRIGHT 1948
GREAT LAKES STEEL CORPORATION

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division • Detroit 18, Michigan
UNIT OF NATIONAL STEEL CORPORATION

NEW MATERIALS AND PARTS

INDEX OF ITEMS

Product	Manufacturer	Page
Abrasion Testing Machine	Taber Instrument Co.	169
Binding Post	Superior Electric Co.	172
Bosses, Weld	The Ohio Nut and Bolt Co.	180
Clamp, Air-Operated	Lapeer Mfg. Co.	169
Cleaning Materials	Hanson-Van Winckle-Munning Co.	180
Contactors, Industrial	Essex Wire Corp.	178
Drawing Pencils, German	J. S. Staedtler	180
Flux Meter, Magnetic	Associated Research, Inc.	180
Handle, Plastic	Consolidated Molded Products Co.	178
Indicator, Thickness	Branson Instruments Inc.	178
Lubricator, Air Line	Hannifin Corp.	174
Nuts, Self-Locking	Prestole Corp.	176
Pyrometer, Portable Electric	Electric-Arc Inc.	176
Recorders, Pen Type	Penn Industrial Instrument Corp.	169
Registration Controller	Photoswitch Inc.	180
Relay, High Speed	Stevens-Arnold Inc.	169
Speed Reducer, Motorized	Fairbanks Morse & Co.	172
Switch, Universal Type	Unimax Switch Corp.	170
Terminals, Tinned Steatite	General Ceramics & Steatite Corp.	176
Tester, Battery and Circuit	Precision Apparatus Co., Inc.	176
Thermometer, Contact-Making	Weston Electric Instrument Corp.	174
Timers, Interval	Gray Laboratory & Mfg. Co.	170
Transmission Drive, Hydraulic	Twin Disc Clutch Co.	174
Transmission, Variable Speed	Standard Transmission Equipment Co.	178
T-Square, One-Piece Plastic	Instrumaster Industries	172
Valve, Air Control	Airmatic Valve, Inc.	174
Valve, Air Hose	Paul Valve Corp.	178
Valves, Balanced Selector	The Parker Appliance Co.	172
Valve, Control	Cochrane Corp.	178
Valve, Furnace Control	Automatic Products Co.	176
Valve, Small Check	Kohler Co.	170
Valve, Solenoid	Johnson Corp.	170
Valve, Two Pressure	The Valv-Trol Co.	180
Voltage Testers	The Square D Co.	176



Abrasion Testing Machine

Taber Instrument Co., North Tonawanda, N.Y.

Model 100-109 is an abrasion testing machine with various sorts of wheels for testing porcelain enamel, organic coatings, leather, glass, plastics and woven fabrics. Having rotary abrading action on a 4 in. specimen, wear results from alternately rubbing the flat faces of two resilient wheels over surface tested. Designed to provide for an additional abraser unit, so that two specimens can be tested simultaneously, instrument is also equipped with an adjustable timer for test periods of 1000 cycles or less. A variable transformer controls the speed of the suction motor to vary the degree of surface cleaning. Front-panel control switches provide combinations of operating conditions such as with or without vacuum pickup, continuous operation without timer, or any control timing up to 15 minutes.

High-Speed Relay

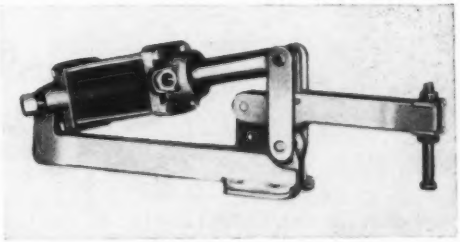
Stevens-Arnold Inc., South Boston, Mass.

Ultra high speed, d-c, Millisec relay is 4 pole, double-throw and hermatically sealed. After energy is applied to coil, about one millisecond is required for contacts to travel to the normal open position, and this time can be reduced to ⅓ of that value by using 3 times the normal voltage. Maximum contact rating is ½ amp 110 v on contacts into a resistive load. Relay is designed to operate with a resistive load, and when so connected, does not need an external spark suppression circuit. Life expectancy of the unit increases from 22 million operations at ½ amp up to 100 million operations at ¼ amp with a rate of 60 performances per sec on contacts. Dimensions are 1 x 1 x 2½ inches.

Pen Type Recorders

Penn Industrial Instrument Corp., Philadelphia, Pa.

Gas-filled temperature recorders and recording pressure gages are available with 1 to 4 pens. Pens require 27 deg arc movement to cover 12 in. circular chart. The Bourdon spring which actuates these pens has a bi-metallic case-temperature compensator, micrometer factory-calibration screw, and protection device so that spring is relieved of strain when pen reaches positive stops at maximum and minimum chart graduations. Bulb design is such that it can be adapted to various apparatus connections. Suitable for temperature ranges from 40 F to 800 F and for pressure ranges from 0 to 2000 psi gage.



Air-Operated Clamp

Lapeer Mfg. Co., Lapeer, Mich.

Model AO-400 Knu-Vise air-operated clamp has a maximum clamping pressure of 400 lb. It is double-acting and will not release clamped work in case of accidental, air pressure failure. Parts held under such conditions will

not be released until the air operating pressure of 85 lb is applied. To produce cushioning effect when opening or closing, the clamp is designed with restricting fittings. This device is applicable in multiple installations controlled by a single valve, or in installations with sequence valves operated at determined intervals.

Interval Timers

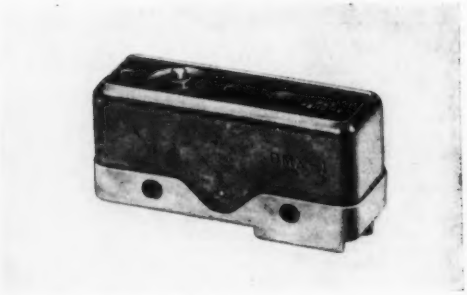
Gray Laboratory & Mfg. Co., Dayton, Ohio

All five models use synchronous motors to measure time ranges from 60 sec to 60 hours. Snap switch with capacity of 10 amp at 125 v automatically switches one circuit on and another off at end of desired time interval. Adjustable reset stop is also provided for repeat operations with the same time interval setting. Models are supplied uncased, but suitable for mounting against a control panel. Buzzer assemblies can also be supplied to operate with panel mounting timers. Standard models for these timers operate at 110 or 220 v, 50/60 cycles.

Small Check Valves

Kohler Co., Kohler, Wis.

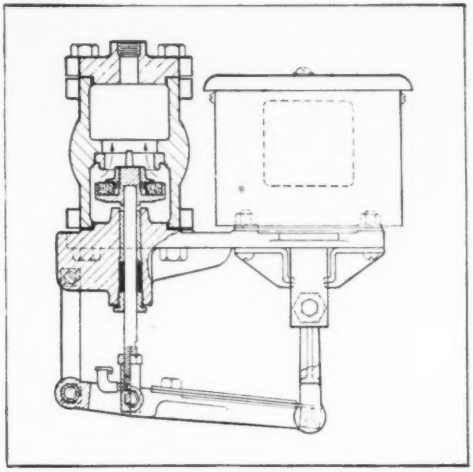
Small check valves are available in $\frac{1}{8}$ to 1 in. sizes with internal or external pipe connections or with tubing connections. Valves are proof tested at 7,500 psi, and have a temperature range of —65 to +160 F. Valve opening pressure can be specified between 0 and 100 psi to meet the application, and the operating pressures can be as high as 3,000 psi. Usable in oil, air, gas, water and other fluid power lines, valves are available in aluminum, brass, stainless steel, or Monel metal.



Universal-Type Switch

Unimax Switch Corp.

With single-pole, single-throw silver contacts capable of handling 10 amp at 125 v, this unit provides for control in apparatus designed for interchangeable use on d-c or a-c circuits. Focused-flux magnet blows out the arc as soon as the contacts open, and a ceramic baffle chamber keeps arc from reaching the contact supporting screws. To permit varied methods of applying operating force, the DMX type switch is provided with a recessed cover which is suited for Unimax Adaptaplates. Dimensions of switch housing are about 2 x 1 x 1 in.,, and assembled unit mounts on 1 in. standard centers. Arc-resistant Melamine is used for molded base and cover.

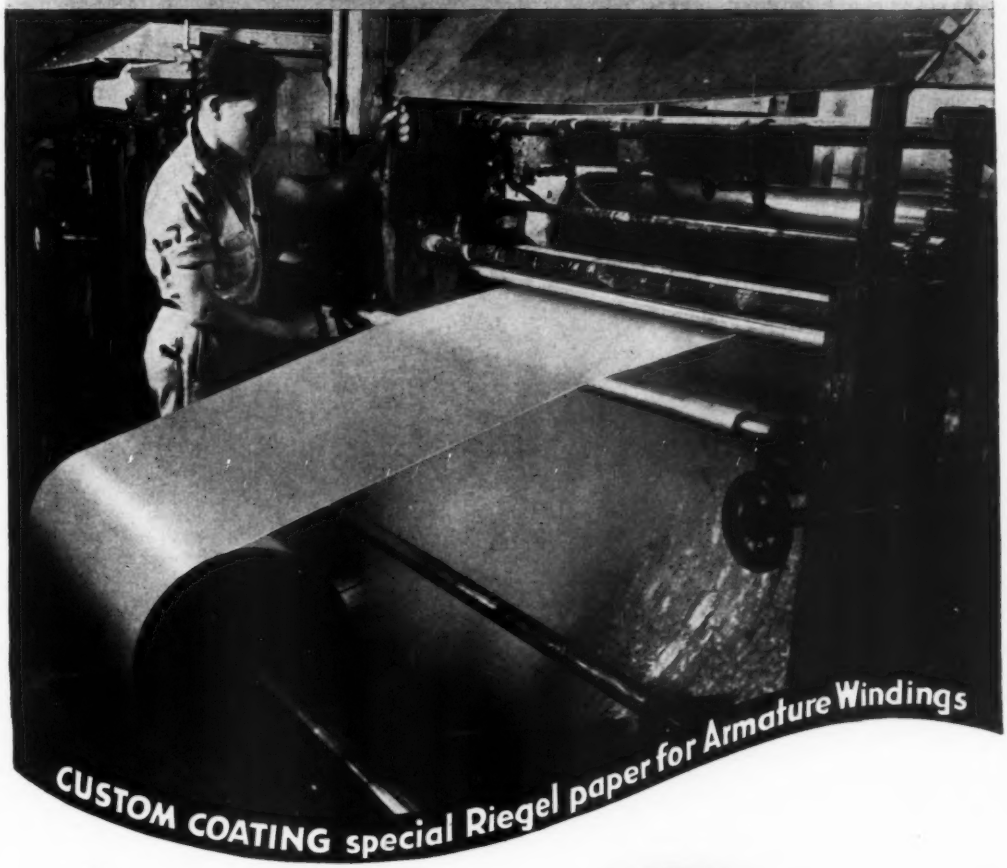


Solenoid Valve

Johnson Corp., Three Rivers, Mich.

Series 6,000 valve is intended for service in which the valve is normally open. In emergency, control element causes solenoid to be energized, thus closing the valve. Since it closes with flow, it will remain closed as long as a pressure of 3 lb exists on inlet side, regardless of whether or not solenoid continues to be energized. To open valve a piping arrangement is utilized. A $\frac{1}{4}$ in. pipe, branching from main inlet pipe, leads directly into cham-

Engineered Papers
CUSTOM-COATED TO YOUR SPECIFICATIONS



Riegel's custom-coated papers are used for many widely varying products and processes, such as armature windings, pressure sensitive tape, laminated plastics, bandage wraps and photographic supplies. We can produce a special paper for you, coating it with lacquer, shellac, hot melt or resins. If you prefer, you can supply the paper, and we will coat it.

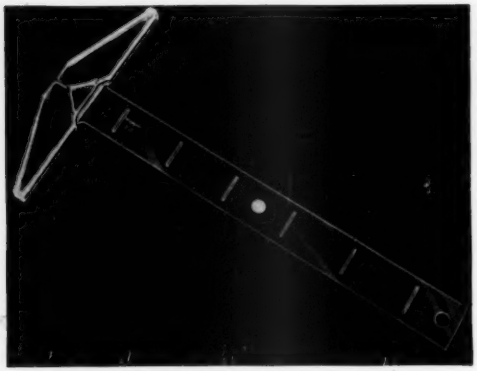
No matter how you want the job done, you can always be sure of Riegel's strict adherence to technical standards. We now produce over 600 papers for industrial leaders in many fields...some grades made for hundreds of customers, some for but a single firm. Write us today. If we can't make exactly what you want, we will gladly tell you who can.

Riegel

Producers of technical papers for industrial leaders since 1862

Riegel Paper Corporation · 342 Madison Avenue, New York 17, N. Y.

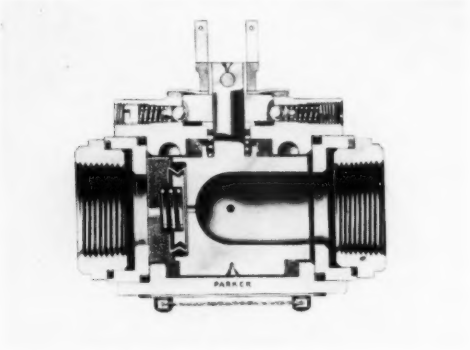
ber on outlet side of valve. Flow through this pipe is controlled by a globe valve. When the latter is opened, pressures on both sides of the main disk are equalized, so control valve opens. Valve body will take pressures up to 150 psi, and main disk construction allows handling of steam, gas, air, gasoline or oil. Available in six sizes from ¾ to 2½ in., valve uses 110, 220, 440 v, 60 cycle alternating current.



One-Piece Plastic T-Square

Instrumaster Industries, 2458-2 W. Jackson Blvd., Chicago 12, Ill.

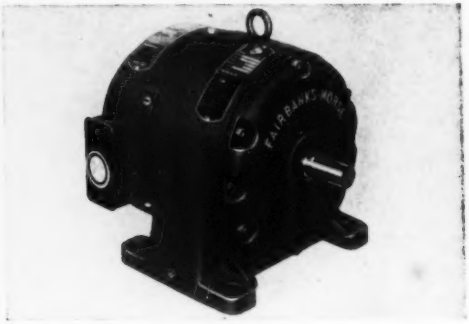
One-piece T-Square made of clear polystyrene plastic maintains its original accuracy after continued use and provides high visibility of surface on which it rests. Both sides of square are equally usable. Ribs protruding 0.020 in. above both faces of the head and at intervals along the length of the blade surfaces lessen smudges when ink is used and reduces friction. Equipment is available in two blade lengths, 18 and 24 inches.



Pressure-Balanced Selector Valves

The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio

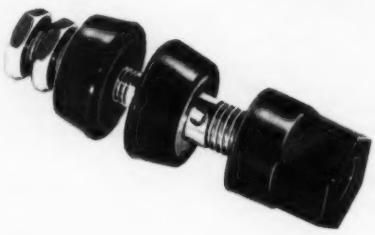
Pressure-balanced valves with up to six operating positions can be adapted for use in air, oil and water systems through the use of various types of sealing elements. Pressure balance is achieved by means of a graphite sealing disk in the central rotor. Disk is drilled permitting fluid to enter a flexible synthetic rubber sac bonded to the back face. A light spring within the sac makes initial port contact, and line pressure is utilized to hold disk against the port. Suitable for pressures up to 50 psi and temperatures from —65 to +160 F, valves are available in ¾ to 1½ in. pipe sizes. Actuation can be manual or electrical. By substituting special adapters, units can be converted for shut-off applications where pressures can be 500 psi and temperatures 450 Fahrenheit.



Motorized Speed Reducer

Fairbanks Morse & Co., Chicago, Ill.

Motorgear is driven by an axial air-gap motor and is available in ratings from ¾ to 10 hp. Machines are symmetrical in design with no separate right or left hand assemblies. Available in 15 different models, the reducers use two ratios of single helical gears that give output shaft rotation speeds from 45 to 280 rpm. The output gear shaft and the motor shaft are concentric. High-speed shaft rotates on ball bearings while low-speed element is mounted on tapered roller bearings. Assemblies are suitable for horizontal mounting, but provisions can be made for wall, ceiling or angle mounting, provided that the shafts remain horizontal.



Binding Post

Superior Electric Co., Bristol, Conn.

Binding post has 5-way adaptability capable of being used for spade lug connection, permanent clamping,

The Story of Formulation 35,032

There's a story behind every one of the 35,031 formulations in the files of the Advance Paint Company.

These 35,031 formulations represent 35,031 individual finishing problems which were turned over to Advance service technicians. In each case, an Advance serviceman inspected both the product and the manufacturing processes involved . . . determined the eventual service and necessary physical appearance of the product . . . checked the type of ovens . . . measured the drying room . . . learned every detail involved in the finishing problem.

The story of Formulation 35,032 can take place in your finishing room. An Advance field representative will come into your plant . . . gather all the details of your finishing problem . . . help to develop a formulation to meet your specific needs.

Manufacturers of Industrial Finishes

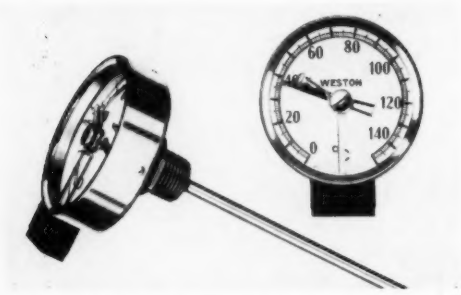
Advance PAINT COMPANY
INDIANAPOLIS, INDIANA

plug-in for banana plugs, looping and clamping and for clip leads. All metal components are recessed for protection and panel insulators are arranged for mounting on material from $\frac{1}{16}$ to $\frac{1}{4}$ in. thickness. Hole in center shaft accommodates up to size 12 wire, and with insert captive and stud hex-shaped head is phenolic plastic. Binding post is rated at 30 amp current capacity and 1,000 v working voltage.

Hydraulic Transmission Drive

The Twin Disc Clutch Co., Hydraulic Div., Rockford, Ill.

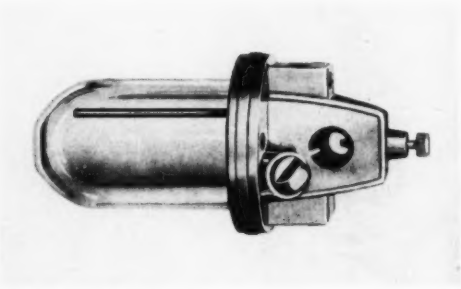
Hydro-Sheave drive is an hydraulic-conversion transmission for electric motors and internal combustion engines in the $\frac{3}{4}$ to 25 hp range. Consists of hydraulic coupling with sleeved shaft that slides over output shaft of motor or engine, thus offering advantages of smooth acceleration and dampening of shock loads and vibrations. Motors or engines can be chosen on the basis of running loads. Unit is reversible as coupling blades are straight and on radial lines. Intended for use with Worthington QD V-Belt sheaves, transmission will accommodate a plate-type chain sprocket.



Contact-Making Thermometer

Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark, N. J.

All-metal thermometer, combining features of temperature indicator and alarm, or control device, contains an adjustable contact arm mounted in the glass and rim. Terminal block mounted on periphery of case provides an electrical connection. Contacts are magnetic, and arm is set to make contact at temperatures indicated on the scale. Although connection can be broken manually after an alarm has sounded, contacts break automatically on a 5 percent temperature change. Accuracy as an indicating thermometer is $\pm$ 1 percent; as a control device, $\pm$ $1\frac{1}{2}$ per cent. Available in stem lengths from $2\frac{1}{2}$ to 24 in., with longer stems for special applications.



Air-Line Lubricator

Hannifin Corp., Chicago, Ill.

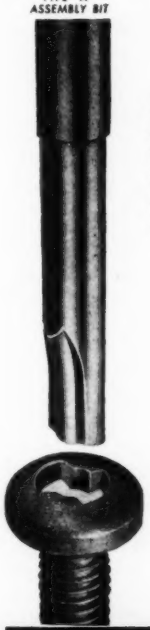
Automatic lubricator for use on lines serving compressed-air operated tools and equipment. Oil is metered into air stream as a fine mist to reduce friction and heating. Consisting of a body to which pipe connections are made and a plastic bowl containing about $\frac{1}{2}$ pint of lubricating oil, construction permits visibility of flow rate which can be controlled by a needle valve. Because removal of an oil filter plug in body automatically shuts off the oil supply, oil is injected only when air is flowing. Air pressure in bowl is thus released to permit refilling without shutting off line pressure. These Series RL lubricators are available in $\frac{3}{8}$ and $\frac{1}{2}$ in. sizes.

Air Control Valves

Airmatic Valve Inc., 1643 E. 40th St., Cleveland, Ohio

Model FC valves are designed for controlling the speed of air being exhausted from machinery actuating cylinders. Positioned between the operating valve and the cylinder,

TYPE "A" ASSEMBLY BIT



Winner of Blue Ribbon Award in Power Driving

COMMON SCREWDRIVER

Engineering and Production Executives vote this award to CLUTCH HEAD Screws on the score of production increases ranging from 15% to 50%... plus the added savings accruing from the elimination of costly skid damage and of burred or chewed-up heads. On the basis of experience resulting from change-over from other types of recessed head screws, here is how these users score CLUTCH HEAD supremacy:

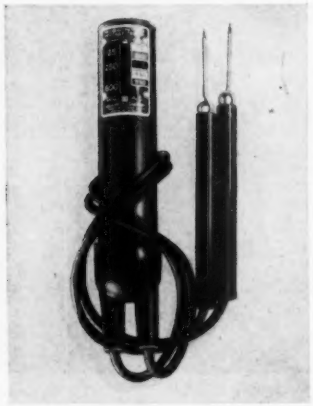
1. High visibility of the clutch recess inspires operator confidence for unhesitating faster driving, while dead-center entry with the Center Pivot Column prevents driver canting. Straight driving is automatic . . . hence no burred or chewed-up heads.
2. Absence of "ride-out," due to CLUTCH HEAD's non-tapered driving engagement, checks out hazard of driver skidding Freedom from end pressure makes driving effortless, safer and smoother for a stepped up tempo.
3. The Lock-On to check out fumble spots . . . screw and bit locking as a unit to permit one-handed reaching and driving from any angle.
4. The unequalled durability of the Type "A" Bit with a record of driving 214,000 screws non-stop . . . plus the economy of its repeatable reconditioning in a simple 60-second operation.
5. The importance of CLUTCH HEAD'S basic design for common screwdriver operation . . . to simplify adjustments and cure field service "headaches."

Make your own test of these exclusive CLUTCH HEAD features. Ask us to mail you screw assortment, sample Type "A" Bit and illustrated Brochure.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

unit affects the speed of the cylinder piston on both the working and return strokes. Screw on top allows for adjustment. Body is Naval bronze and working parts are stainless steel. Applicable to air, oil and water systems, valves can handle pressures to 1,000 psi. Ports are threaded to fit $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 and $1\frac{1}{4}$ in. standard pipes.



Voltage Testers

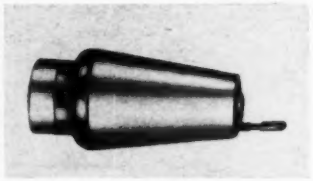
The Square D Co., Detroit, Mich.

Two voltage testers, one designed for high frequency alternating systems and the other for low voltage systems, require no lamps for operating. High frequency tester is suitable for systems ranging from 110 to 550 v at 400 cycles a-c and 30 to 120 v d-c. Low voltage instrument can be used for systems ranging from 12 to 60 v at 60 cycles a-c and 10 to 40 v d-c. Rubber coverings protect test leads, and shear points allow operator to obtain voltage ratings by piercing the insulation without damaging it.

Self-Locking Nuts

Prestole Corp., Toledo, Ohio

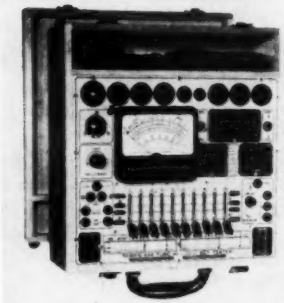
Self-locking nuts, suitable for both 8A and 10A sheet metal screws, are blind-location fasteners applied from assembly side instead of reverse side of panel. Nut fits into a 9/32 in. square hole in panels 0.037 to 0.055 in. thick. As the screw is driven, the arched spring arms of the nut expand and follow the contours of the thread roots, thus locking the fastener to the panel. Made of 0.025 in. heat-treated spring steel, nuts are available with zinc chromate, plain, or cadmium plated finishes.



Tinned Steatite Terminals

General Ceramics and Steatite Corp., Keasbey, N. J.

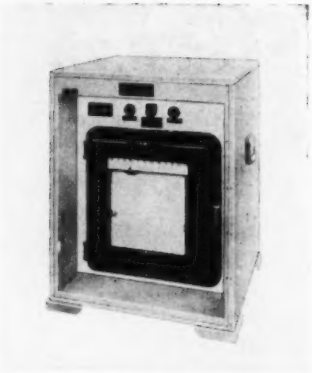
Terminals for use on metal enclosures are made of Grade L-5 Steatite and glazed on the outside. The silver surface on the top and shoulder is copperplated, and the copper surface is hot tinned. Leads are brought through an axial opening in the bushing and are soldered to a tinned lug at one end of the terminal. Also available are terminals containing a solder suitable for operation at 200 F to meet the newly proposed specification.



Battery and Circuit Tester

Precision Apparatus Co., Inc., Elmhurst, L. I., N. Y.

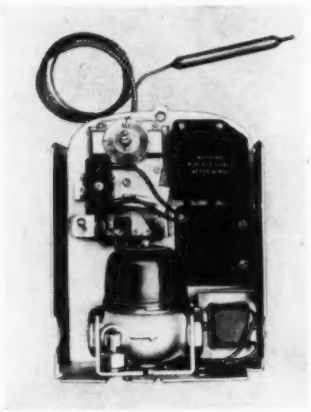
A combination cathode conductance tube tester, battery tester, and a-c and d-c circuit tester, Series 664 is a laboratory instrument designed for electronic technicians. Tester includes micro-line adjustment, fuse extractor post, telephone-type cabled wiring, a 50 microamp meter, 1 percent wirewound and film type resistors, and free-point lever selection. For circuit testing the instrument has 5 d-c voltage ranges and 6 d-c current ranges, 5 a-c and output voltage ranges from 0 to 6,000 v, 3 resistance ranges from 0 to 600,000 ohms, and 5 decibel ranges from —12 to +70 db. All standard ranges require only 2 pin jacks.



Portable Electric Pyrometer

Electric-Arc, Inc., Newark 8, N. J.

Pyrometer, run by either automatic or manual operation, is designed so that 6 deg heat range from 0 to 2,200 F can be recorded or controlled. Because unit is portable, it can be used in steel mills and chemical plants for temperature control of heating processes. Suitable for semi-automatic, or completely automatic heat cycle, program control, instrument weighs 100 lb, and its dimensions are 30 x 24 x 22 inches.



Furnace Control Valve

Automatic Products Co., Milwaukee, Wis.

Gaspack is a unit for water heater, gas furnace and space heater applications. It is built around a solenoid valve, electric pilot and pilot filter. In place of thermostat rod, valve uses a feeler bulb strapped to the outside of tank. Valve disk provides positive

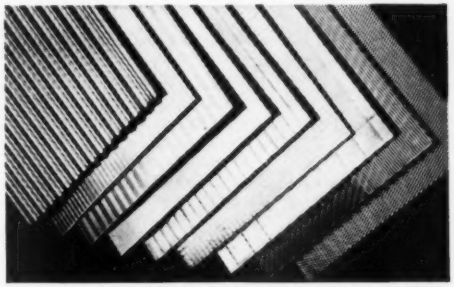
Plated Parts Move From Raw Material To Assembly Line In Two Operations

Manufacturing has been simplified in hundreds of plants through elimination of former methods which required cleaning of stamped parts, plating, polishing or other finishing, before going into final assembly. By substituting pre-plated Nickeloid Metals a streamlined, economical result has been achieved. In many plants Nickeloid Metals are (1). Blanked. (2). Stamped or formed. Then assembled. Handling, factory space, and equipment investment has been reduced or eliminated. Nickeloid Metals are available with finishes of Chromium, Nickel, Copper, Brass, Tints, or Gold Bond . . plated to such base metals as Zinc, Steel, Copper, Brass, or Aluminum. Attractive patterns and finishes, saving other steps, also available.

Representative Nickeloid Metals have been put up in an attractive and useful SAMPLER. Send for a copy on your company stationery.

BLANKING First step. With proper dies and good shop practice, the highly plated finish of Nickeloid Metals is not impaired. For unusually severe operations, Mar-Not protective finish is available.

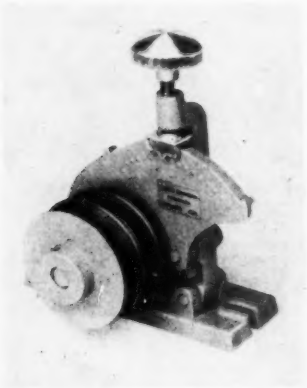
STAMPING Beautiful results are achieved. Nickeloid Metals may also be riveted, soldered, spot welded, seamed, etched. Illustration below shows stamped part after ejection from stamping machine.



The wide variety of finishes and attractive patterns of Nickeloid Metals makes them a source of inspiration to the product designer. The company supplies samples to aid designers in employing these metals.

AMERICAN NICKELOID COMPANY
PERU 4, ILLINOIS

shut-off on natural, manufactured and LP gas. Pilot can be mounted in any position. Pilot thermal element on both water heater and furnace models has no moving parts in heated zone. If current fails the furnace valve can be operated manually; and when current is restored, unit automatically returns to control by thermostat. Capacity of water heater control valve is 35,000 Btu/hr for manufactured gas, and 55,000 Btu/hr for natural gas.



Variable Speed Transmission

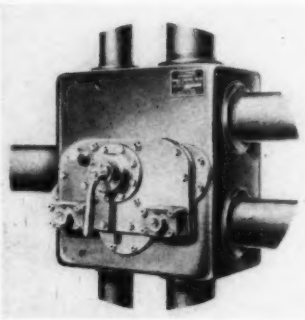
Standard Transmission Equipment Co., Pasadena, Calif.

Improved variable speed reducer designed for applications where a 3.3 to 1 speed range and A section V belts can be used. Speed adjustments can be made while machine is in operation. A hardened ground shaft rotates in a sealed, double ball bearing assembly. The two outer pulley flanges are fixed to the rotating shaft with the center pulley floating laterally on a bronze bushing over that shaft. Overall width and height of machine is 6½ by 9 inches.

Air Hose Valve

Paul Valve Corp., New York 17, N.Y.

For air lines up to 100 psi, this valve contains no springs or packing but operates on an engineering application of Bernoulli's theorem. A small ball, when not held down by a thumb-operated plunger, automatically seeks the high-velocity, low-pressure center of the air stream. By so doing it becomes positioned on a valve seat to stop the air passage. Valve is available for ⅜ and ¼ in. hose sizes.



Control Valve

Cochrane Corp., Philadelphia, Pa.

Control valve for ion exchange systems and pressure filters is a six position valve with 2 standby and 4 normal operating positions. Unit contains backwash and rinse rate controllers which reduce space and attention requirements. Valve is pilot-actuated with power for operation of the valve members provided by the water. Small disk-type pilot valve also permits gradual opening and closing of the valve members. With pressure filter installations, the valve can be adapted to operate with various kinds of chemical feeding systems or with actuation of filter agitators.

Industrial Contactors

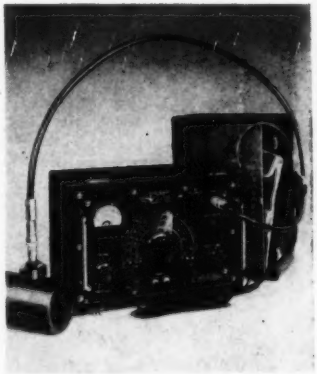
Essex Wire Corp., Logansport, Ind.

Industrial contactors designed for operation with a-c current at 600 v maximum are best suited for machine tools, electric furnaces, sequencing and processing control panels. Contactors are arranged for 2-wire control, but nonreversing contactors can be wired for 3-wire control by using one normally open contact as a 3-wire control electrical interlock. Steel base with neoprene mounting grommets permits mounting on a grounded surface without further insulation. Provided with E-type magnet and floating armature and 50/60 cycle continuous duty coils, contactors are available in 10 or 15 amp non-inductive ratings in from 2 to 8 pole construction.

Plastic Handle

Consolidated Molded Products Corp., Scranton, Pa.

Handle for vacuum-type coffee makers includes a double-thumb rest on top of handle arch, and underside finger channels for steady grip. Made of molded, asbestos-filled, heat-resistant, phenolic plastic, the handle has two holes for the accomodation of bolts connected to a metal strap which secures the handle to the container.

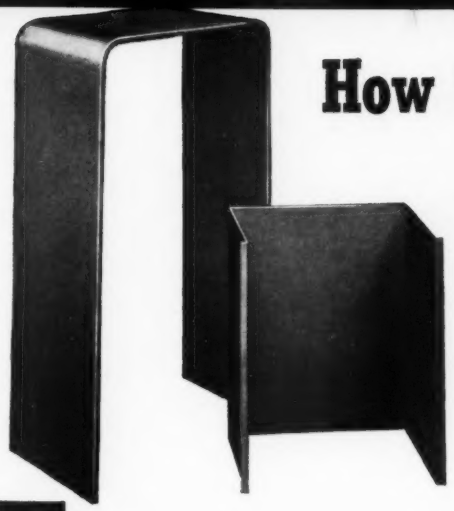


Thickness Indicator

Branson Instruments, Inc., Danbury, Conn.

The improved thickness indicator, Model FMSS-5 is used for non-destructive thickness measurement of metals, glass, plastics and other materials. The instrument operates by transmitting ultrasonic waves into the material under test. By tuning the frequency of these waves to resonant frequency in the tested material, the resonant frequency value found can be converted to thickness. Readings obtained are the actual wall thicknesses of the material; makeup liquids and scale deposits are not measured. Incorporated in the improved design is adjustable frequency modulation to facilitate the measurement of badly corroded material; a permeability tun-

How to *Form* metal cabinets on a PRESS BRAKE!



By extending bed and ram beyond the ends of the press and installing tangent bending mechanisms, BATH has added cabinet forming to the already wide range of functions of its STURDYBENDER Press Brake.

Now it is possible to do a complete job on one machine—blanking, perforating, notching, bending of flanges *and forming*. Obviously, this method provides a tremendous savings in the handling of materials, and eliminates the need for special forming equipment. The tangent bending mechanism is adjustable, to permit forming a wide variety of shapes. Cabinets for refrigerators, washing machines, deep freeze units, vending machines and other similar products are already being formed by this means.

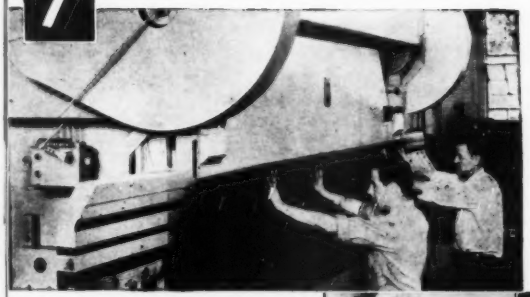
Since more and more manufacturers are finding the STURDYBENDER tangent bending device an economical answer to their cabinet forming problems, you, too, may be interested in the details. A letter will bring full information.

The CYRIL BATH COMPANY

6987 MACHINERY AVENUE

CLEVELAND 3, OHIO

1

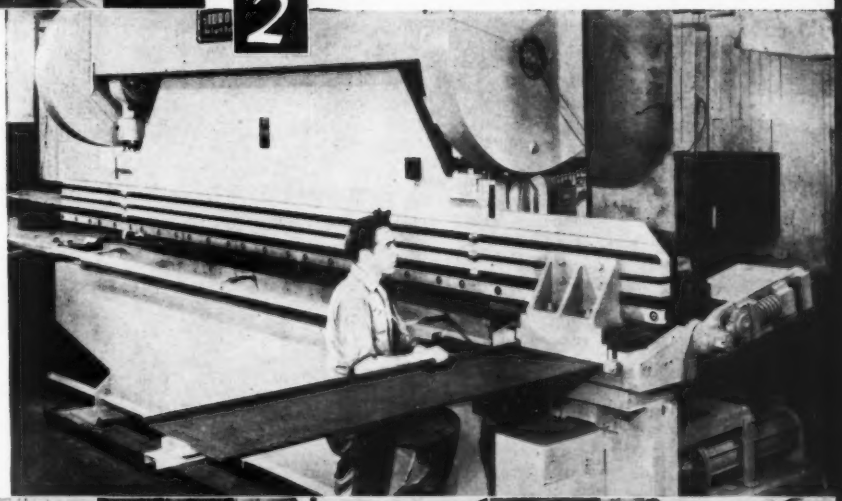


2

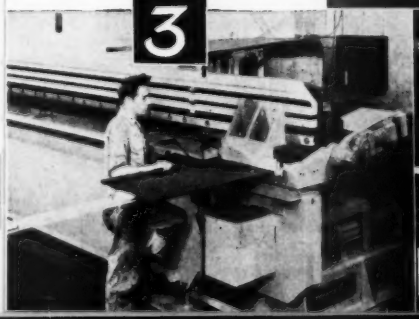
First step in production of refrigerator shell is forming 90° flange and lock flange on sides of flat sheet, conventional press brake operations.

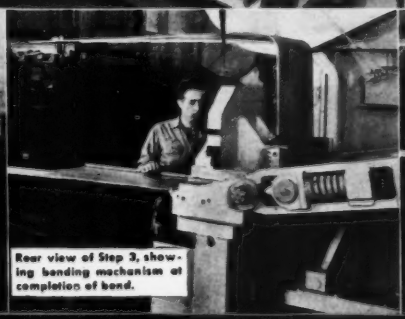
Sheet is then inserted in tangent bending device and the first top corner bend is made. Buckling or wrinkling of flanges at the corner radius is avoided.

Sheet is moved further into the machine and second corner is formed. Once machine is set up, duplication of parts is automatic and very accurate.



3





Rear view of Step 3, showing bending mechanism at completion of bend.

Same view except that bending mechanism has been returned to starting position.

ing unit to increase sensitivity of frequency range; and increased frequency range for measurement down to 1/16 inch. Special ranges can be provided for thinner material. Instrument is portable and battery operated, but a-c power supply can be used.

Registration Controller

Photoswitch Inc., Cambridge, Mass.

Type 23LF3 is used with automatic packaging, labeling, printing and cut-off machinery working on paper, cellophane, fabrics, steel, tin, aluminum and other sheet material. Circuit will respond to impulses as short as 1/1,000 sec. Design includes the split-beam scanning head. Light source and phototube are served by a single lens, handling both transmitted and reflected light. Instrument operates on either opaque or transparent web materials, and controls both light and dark registration marks. Instrument can be used to control continuous or intermittent feed machines, and requires a 115 v, 60 cycle supply.

Cleaning Materials

Hanson-Van Winckle-Munning Co., Matawan, N. J.

Type 20-W is a non-etching cleaner, and can be used as a soak cleaner for aluminum or for zinc-base die castings. Type 25 is non-silicated caustic base cleaner for etching aluminum, and type 30 has a silicated caustic base with no foaming or wetting agent so that it is applicable in spray type washing machines for steel parts. Number 50-W is a non-silicated, high caustic base cleaner used as a soak solution for the cleaning of magnesium.

Two-Pressure Valve

The Valv-Trol Co., Akron, Ohio

Two-pressure valve is an assembly of three independent valves which are installed as a unit. Low pressure is admitted to the three-way valve through an angle check valve. The latter prevents high pressure from entering low pressure system. High pressure is introduced through an automatic inlet. Changes in rate of flow are made gradual by skirted inner valve. Bodies are of bronze alloys and tops are of steel diaphragm construction. Low and high pressure sides are rated at 700 and 3,500 psi, respectively. The 5 models available give a range of pipe connection sizes from ¾ to 2½ in. on low pressure side, and ½ or ¾ in. on high pressure side.

Weld Bosses

The Ohio Nut and Bolt Co., Berea, Ohio

Weld bosses, made for projection welding to sheet metal and thin metal plates, are used to increase thickness of the metal to provide bearings for shafts or push-rods, or to provide a surface for tapping or threading. Thicknesses range from ¼ to ¾ in., and shapes are round, square and flanged. The round and flanged bosses are available in low carbon steel, brass or 18-8 stainless steel. Square bosses are provided in either low carbon steel or brass. Hole diameters run from 0.104 to 0.638 inches.

German Drawing Pencils

J. S. Staedtler Inc., N. Y. C., N. Y.

The Mars-Lumograph drawing pencils are again being imported from Nurenburg, Germany. Available in 17 degrees of hardness from 6B to 9H, they are manufactured from finely milled clay and graphite.

Magnetic Flux Meter

Associated Research Inc., Chicago 7, Ill.

Model 327 meter measures a-c, d-c and transit magnetic flux densities. Some of the uses to which the instrument can be put are: to check field strengths when magnetizing permanent magnets, to find strength and field distribution of motors and generators, and to determine extent of field distortions due to armature reaction. Various sizes of probes can be supplied to suit specific measurement applications. In operation the maximum Gaussometer readings are applied to the graph on the inside of instrument cover to find flux. Connections are also provided for oscillographic studies of flux. Although special ranges are available, the standard range of the equipment is 0 to 26,000 Gauss calibrated to an accuracy of 1 percent.

Save time on machine design ...specify the complete CRANE line

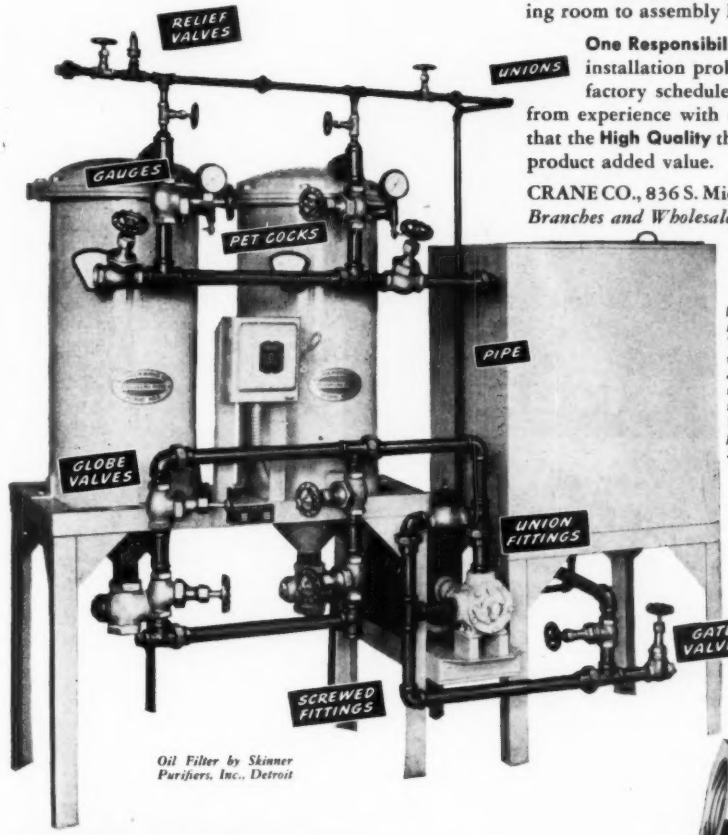
ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

Why spend time hunting for piping equipment when you can get everything from Crane? One catalog . . . well organized for quick, easy reference . . . gives you a comprehensive selection from the world's most complete line of brass, iron, steel and alloy piping materials.

Take this Oil Filter, for example. All valves and fittings, pipe and pipe line accessories are from Crane. And regardless of the design on your boards, specifying Crane as your **Single Source of Supply** helps to speed and simplify all piping procedures, from drafting room to assembly lines.

One Responsibility for materials helps smooth installation problems, assures better control of factory schedules. And your customers know from experience with other Crane piping they buy, that the **High Quality** that is Crane Quality gives your product added value.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas



Oil Filter by Skinner Purifiers, Inc., Detroit

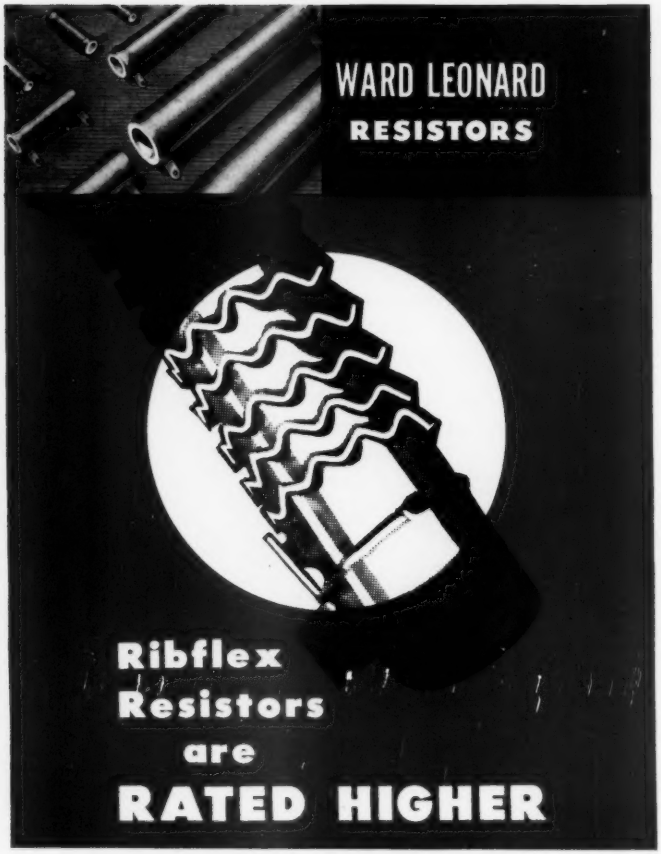
FOR THROTTLING *and other severe services—Crane recommends No. 14¼P Plug Type Disc Brass Globe Valves. Extra wide seating surfaces offer higher resistance to wire drawing; tapered disc permits easy regulation of flow. Seating materials: Crane Nickel Alloy to Exelloy. Working pressures: 150 pounds steam; 300 pounds cold water, oil or gas, non-shock. Sizes up to 3 in. See your Crane Catalog, page 31.*

EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM



because the element has MORE SURFACE

Additional surface for heat dissipation means higher watt ratings for Ward Leonard Ribflex Resistors, 85% to 95% higher than ordinary wire-wound resistors of same size.

Whether for continuous or intermittent duty, the high watt rating and low ohmic values make them first choice for a wide variety of heavy duty applications.

Write for Resistor Catalog. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

NEW BOOKS

Engineering Applications of Fluid Mechanics

J. C. HUNSAKER, *Department of Aeronautical Engineering, Massachusetts Institute of Technology; and* B. G. RIGHTMIRE, *Department of Mechanical Engineering, Massachusetts Institute of Technology.* 494 *pages,* 9 x 6 *in. Published by McGraw-Hill Book Company, Inc.,* 330 *W.* 42 *St., New York* 18, *N.Y.* $5.

This text is the basis for an introductory course in fluid mechanics and is built upon some twelve years experience in teaching the subject at M.I.T. The theory of mechanics of fluids gives an exact description of flow phenomena only for certain idealized cases. In applications, the effect of friction and the resulting turbulence cause a type of flow too confused to be postulated mathematically. Models have been used with great success to solve complicated problems of this nature. For this reason an understanding of dimensional analysis and similitude is necessary to insure that model experiments will predict full scale behavior. Therefore, the authors have gone into the theory of dimensions and physical similitudes with some care.

The theoretical behavior of an ideal friction of fluid has been discussed to introduce to the students basic concepts governing pressure and velocity distribution. The first part of the book treats kinematics, dynamics of an ideal fluid, energy relations for steady flow, momentum relations for steady flow, dimensional analysis and incompressible flow in closed conduits. The latter part of the book covers compressibility phenomena, drag, wing theory, hydrodynamic lubrication, hydraulic turbines, pumps, fans, compressors, propellers, jets, torque converters and hydraulic transmissions and controls. Material on servo-mechanisms is also included in this volume.

Patent Law for the Executive and Engineer

H. A. TOULMIN, JR., *patent attorney, Toulmin & Toulmin. Second edition.* 231 *pages,* 5½ x 8 *in. Published by Research Press, Inc., Dayton, Ohio.* $2.95.

This book is a practical discussion of patent law which shows the layman how to develop and protect his invention in order to make it profitable. A complete revision of the original edi-

tion put out in 1928, this volume incorporates the most recent decisions of the United States Supreme Court. Subjects discussed include: How to get a valid patent; when to consult a patent attorney; how to keep invention records; how to stimulate invention by employees; how to avoid patent infringement; how to obtain patents abroad; and protecting research profits.

Metallography

ROBERT S. WILLIAMS *and* VICTOR O. HOMERBERG. 319 *pages,* 6 x 9 *in., fifth edition. Published by McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $4.

This is a textbook of metallography for engineering students. In its development, greater emphasis has been laid in the applications of metallography rather than the physico-chemical principles involved. However, there is included a discussion of the fundamental principles on which metallography is based. The subject is roughly divided as follows: The simple alloy diagram; the alloy diagram and its meaning; plastic deformation and annealing of metals; nonferrous alloys of technical importance; iron and steel; the macroscopic examination of steel; and laboratory methods.

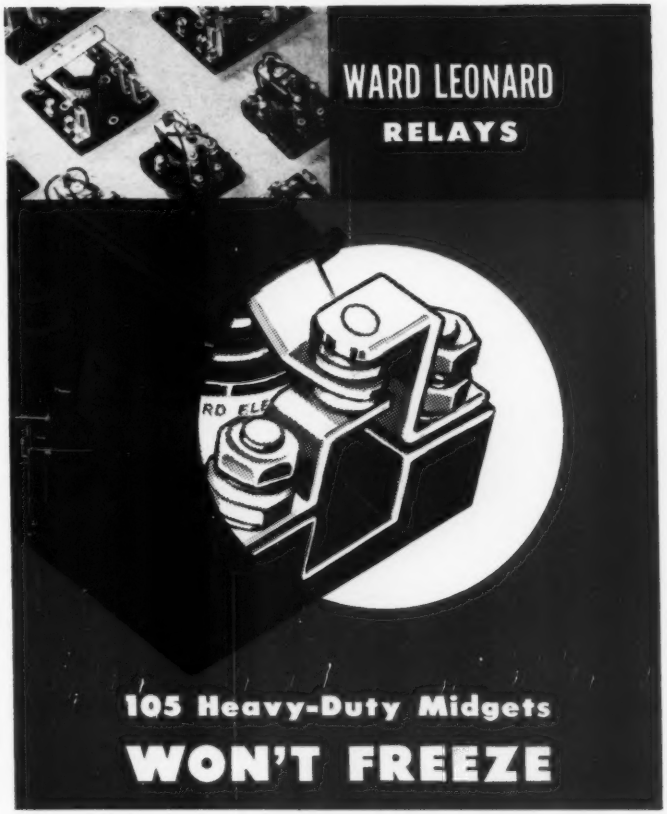
In this new edition the text has been revised in the light of the many changes in alloy practice necessitated by the demands of the last war. The sections dealing with copper, magnesium and aluminum alloys have been rewritten and enlarged in the light of recent developments. New material has been included in the discussion of alloy steels, cast irons and case hardening. Also, a discussion of "hardenability" has been added.

Sequential Analysis

ABRAHAM WALD, *Professor of Mathematical Statistics, Columbia University.* 212 *pages,* 9 x 6 *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $4.

This is said to be the first book-length treatment of a theory for statistical inference. It is on the mathematical level of a reader who has covered college algebra and a first course in calculus. Some knowledge of probability and statistics is desirable though not essential. Mathematical derivations of a more intricate nature are put into the appendix, which can be omitted without impairing understanding of the rest of the book.

Through the techniques described, possible errors committed by wrong



because contacts get a GENEROUS WIPE

Unique spring suspension adds a self-cleaning action to the heavy, silver-to-silver contacts of Ward Leonard's 105 Heavy-Duty Midget Relays. These features make them self-aligning, too.

Use Ward Leonard 105 Midgets on jobs normally requiring heavier relays.

Write for Relay Catalog. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

MARTIN-HUBBARD CORPORATION

Engineering Consultants

Computers — Servomechanisms

Instrumentation for Nuclear Research

Applied ultrasonic research and development

Design and construction of scientific instruments
to your performance specifications

Complete engineering of original or unique electrical
and mechanical devices and machinery

Technical reports

11 BEACON STREET

BOSTON 8, MASSACHUSETTS, U. S. A.

Telephone: CApitol 7-6990 Cable Address "MARHUB-Boston"

More than 60 years of leadership and experience in developing special purpose cloths for industry. With such a background of experience it is little wonder that Holliston Tracing Cloth is second to none. Try MICRO-WEAVE.

To say that repeated erasures and redrawings on tracing cloth leave *absolutely* no semblance or trace of feathers to snare the unwary pen is — well, that is a bit too strong a statement. This applies to all tracing cloth.

But we do say this, without fear of contradiction — repeated erasures and redrawings made on Holliston MICRO-WEAVE Tracing Cloth leave a *minimum* of feathering.

Exaggeration wins no customers. Modest claims — maximum uniform transparency, ready erasability, cleaner sharper blueprints, no pin holes or thick threads — are made for both MICRO-WEAVE Pencil and Ink Tracing Cloth. These qualities can easily be verified and proved on your own drawing board. Write for generous sample. Test and be convinced.

THE HOLLISTON MILLS, INC.
CHICAGO NORWOOD, MASS. NEW YORK

decisions are controlled as effectively as the best current procedure based on a predetermined number of observations. Yet this technique substantial reduces the number of observations necessary. In other words, the sequential analysis is a method of statistical inference in which the number of observations required by the procedure is not determined in advance of the experiment. The decision to terminate the experiment depends, at each stage, on the results of observations previously made. The author's work was done for the Bureau of Ordnance, Navy Department, 1943, in connection with military equipment.

The first part of the book reviews the current theory of testing statistical hypothesis. Chapter 2 discusses the sequential test of a statistical hypothesis. The third chapter applies the sequential probability ratio test for testing a simple hypothesis against a single alternative. The next chapter outlines the theory of testing simple and composite hypotheses against a set of alternatives.

The second part of the book discusses application of the general theory to special cases such as testing the means of a binomial distribution and finding the mean of a normal distribution when a known standard deviation falls short of a given value.

Part 3 investigates multi-value decisions and estimations.

Compressed Air Handbook

Compiled and edited by Educational Committee and the Technical Committee of the Compressed Air and Gas Institute. 387 *pages,* 6 x 9 *in. Published by the Compressed Air and Gas Institute,* 90 *West St., New York* 6, *N. Y.* $3.

It long has been recognized that a collection of data from manufacturers and users of air operated devices and air compressing equipment would be a valuable addition to the literature. The Compressed Air Handbook represents an attempt by the Compressed Air and Gas Institute to do just this.

The first two sections are a collection of typical applications of compressed air and gas, and of representative types of compressor installations. As such, they are interesting and generally informative. The remaining sections on portable air operated tools and rock drills, engineering the compressor installation for maximum efficiency, and compressed air engineering data and test procedure include detailed engineering information useful to all users and designers of compressed air equipment, especially since much of the information is packaged in the forms of tables, charts and

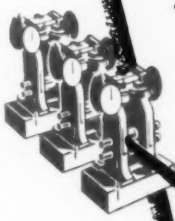
HOW SANDVIK "Custom-Tailors" SPRING STEELS FOR SPECIAL SERVICES

By *analysis, gauge, width* and *finish* each type of SANDVIK spring steel is fitted to a specific service.

SANDVIK has a wide variety of these specialized, high carbon and alloyed strip steels. They are supplied:

- In special analyses for specific applications
- Annealed, unannealed or hardened and tempered
- Precision-rolled in thicknesses from .001"
- With bright finish or blue or yellow polished
- With round edges or square edges
- In a wide range of widths

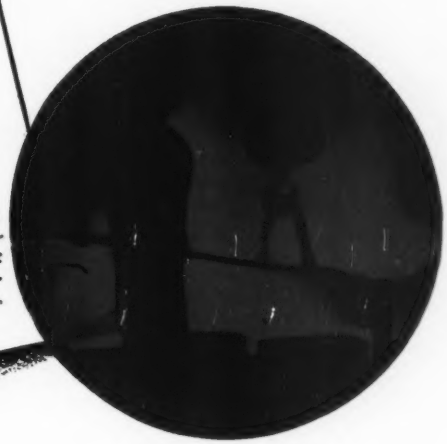
If you have an application that requires something extra in spring steel performance, check with SANDVIK. Phone or write for further information, technical advice or current stock lists.



BY COMPOSITION

SANDVIK steels are made in special analyses to meet the demands of specific types of service.

Made from very high grade ore . . . smelted with charcoal . . . combined with selected scrap and refined in small furnaces affording more accurate control . . . SANDVIK steels have inherent high quality.



BY PROCESSING

SANDVIK's specialized experience, skill and equipment custom-process the steel strip to the exact gauge, width and finish required for the application.

SOME SANDVIK SPECIALTY SPRING STEELS

Band Saw Steels • Camera Shutter Steel • Clock and Watch Spring Steels • Compressor Valve Steel Doctor Blade Steel • Feeler Gauge Steel • Flapper Valve Steel • Knife Steels • Matrix Band Steel Piston Ring Segment and Expander Steels • Razor Blade Steel • Reed Steel • Shock Absorber Steel Sinker Steel • Spring Steels • Textile Steels • Trowel Steel • Vibrator Reed Steel

Sandvik

SANDVIK STEEL, INC. • 111 Eighth Ave., N. Y. 11, WAtkins 9-7180
180 N. Michigan Ave., Chicago 1, Ill., FRAnklin 1745
1736 Columbus Rd., Cleveland 13, Ohio, CHerry 2303
WAREHOUSES: New York and Cleveland

SS-35

Silicone News

DC SILICONES

Flying Jennys to Jets

In the days of the flying Jenny and the cow pasture airport, comfort was a luxury few airmen had time to consider. Keeping out of the tree tops was a more constant problem than keeping fingers from freezing. But in the sleek new airliners, passengers expect drawing-room comfort. That requires creative engineering because both high and low temperatures are involved and only such relatively new materials as the Dow Corning Silicones can take both extremes.

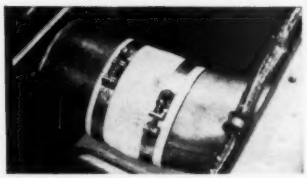


PHOTO COURTESY ARROWHEAD RUBBER CO.

Silastic-coated glass cloth heating duct seals withstand continuous long time exposure to operating temperatures between 350° and 400° F. in new Consolidated Vultee Convair-Liners.*

In designing the new Convair-Liner, Consolidated's engineers faced heating and ventilating duct conditions that would frizzle any conventional material; maximum temperature 450° F.; operating temperature, 350°-400° F.; internal air temperature, 250°-350° F.; internal pressure, 10 in. of water; misalignment, $\frac{1}{8}$ to $\frac{1}{4}$ inch; vibration from mild to extreme.

That's the problem Consolidated presented to Arrowhead Rubber Company of Vernon, California. In 10 days engineers at Arrowhead solved this problem with a combination of Silastic on glass cloth. Arrowhead also uses Silastic, the rubber-like silicone by Dow Corning to produce duct seals that have high performance records at temperatures from —89° to 450° F. and under pressures up to 150 p.s.i. in the newest army jets.

For the properties of Silastic phone our nearest branch office or write for pamphlet No. F5-H.

*TRADE MARK REGISTERED U. S. PAT. OFF.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
Atlanta • Chicago • Cleveland • Dallas
New York • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

graphs so that it can be easily extracted. Essential formulas are included, and line drawings and photographs are used to illustrate specific problems or applications.

Mechanics

J. P. DEN HARTOG, *Professor of Mechanical Engineering, Massachusetts Institute of Technology.* 440 *pages,* 6 x 8⅞ *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York,* 18, *N.Y.* $4.50.

This two-semester course textbook for second or third year engineering students is presented by an authority in the field. Judging by the tone and the words of the preface, the author decided that here would be at least one textbook written with the reader's sensibilities in mind. While the text is clear, concise, and accurate, the author has drawn his analogies and examples from everyday experiences, avoided excessively formal language and used personal pronouns. The result is a refreshingly readable textbook, and one that possibly gains in clarity because the reader so quickly feels at home.

Battlefronts of Industry
Westinghouse in World War II

DAVID O. WOODBURY, 342 *pages,* 6 x 9 *in. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, Limited, London.* $3.50.

Although intended as a record of the role played by the Westinghouse Electric Corporation, during and immediately preceeding World War II, this book, in one sense, is the record of all American industry, for it charts the behind-the-scene struggles and achievements that were necessary to make America "the arsenal of democracy."

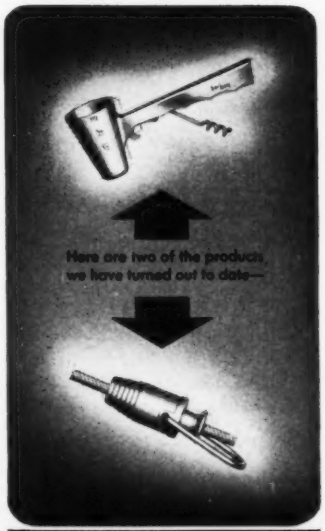
Starting in 1940 with the revision of the Neutrality Act, the author develops the general conditions that prevailed within industry in general, and within Westinghouse in particular. Just prior to that revision, at a meeting of company executives in New York, a program for the manufacture of goods vital to the war effort was developed and adhered to throughout the war. In general, it stated that the company would take on a relatively small number of major products rather than a large number of minor products; would try to select the projects that were best suited its experience; and would locate and build new buildings so as to fit into a long-range expansion program for regular peacetime projects. In short, the company would build what it knew how to build, what

The LID is OFF!

Here is a birds-eye view of a new manufacturing plant. These facilities are immediately available to take over the *entire* production of that new product you have in mind—particularly if the principal components of the product are adaptable to high speed production by the die casting process. Or perhaps you have an established product which, under your present setup, is not showing an attractive margin of profit.

Under one roof, the Newton Industries plant houses modern equipment and competent personnel to handle all phases of production for your product—die casting, machining, assembling, packing and shipping. All you need do is tell us where, when and how many to ship.

You are cordially invited to visit with us in West Haven and view our facilities from ground level.



NEWTON Industries INC.
101 SAW MILL ROAD — WEST HAVEN, CONN.

NATIONAL OIL SEAL LOGBOOK

USE OF OIL SEALS IN HIGH SPEED MECHANISMS WHEN EXTREME OPERATING CONDITIONS EXIST

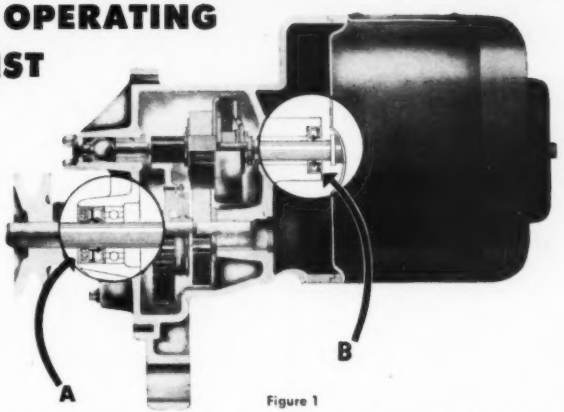


Figure 1

Specifying the right oil seal is particularly important when fine-tolerance machines must operate under unusually adverse conditions.

Frequently, precision assemblies such as gear head motors operate for long periods of time in heavy dust and dirt conditions. Speeds exceed 2,000 RPM, lubricant pressure heads must be contained, torque must be held low, and space limitations in the housing area are often critical.

EXCLUDING DUST, DIRT

Typical of such sealing problems is the gear head motor in Figure 1. Here seals are required at A and B. Seal A retains gear box lubricant and excludes abrasives. Under average dust and dirt conditions, a single-wipe, spring-loaded synthetic rubber seal (Figure 2) is effective. However, when abrasive hazards are great a double-wipe seal with an auxiliary sealing member of leather, felt or rubber (Figure 3) is indicated. When speed is low and dirt conditions are severe, the auxiliary should be rubber. At medium speeds with heavy abrasive conditions, a leather auxiliary is often used. At high speeds with lighter abrasive conditions, a felt auxiliary is effective.

SEALING FLUID HEADS

At B in Figure 1, the application requires an absolute seal between motor and gear box. Spring-loaded, synthetic-rubber, single-wipe seals are effective with moderate or heavy pressure heads. For very heavy pressure heads, special pressure-type synthetic rubber single-wipe seals are used when speeds are not high. For extreme pressures and speeds, a special "face-type" seal is often required. On the other hand, *springless* seals (Figure 4) can often be used for very light pressure heads, when shaft size is small. These seals have proven ideal in many cases where water or industrial fluids are to be sealed, and speeds are relatively low.

SPECIAL SEALS

However, when abrasive, speed, space or other extremes exist, the sealing problem is often solved only through the design of a special seal. National Oil Seal Engineers have helped design and build many such seals. They have also assisted designers in the application of National Oil Seals from stock. Before specifying seals, consult with the nearest National Engineer, or write direct to our Redwood City, California, home office. All data is held confidential.

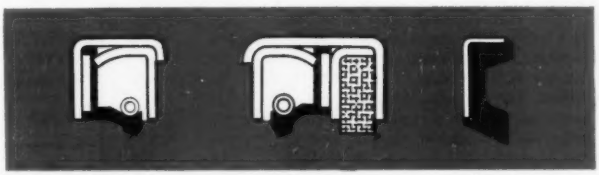


Figure 2 Figure 3 Figure 4

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

BUFFALO: 56 Arlington Place, Grant 2280. **CHICAGO:** Room 2014 Field Building, Central 6-8663. **CLEVELAND:** 210 Heights Rockefeller Building, Yellowstone 2720. **DALLAS:** 30½ Highland Park Village, Justin 8-8453. **DETROIT:** Room 1026 Fisher Building, Trinity 1-6363. **HOUSTON:** 6731 Harrisburg Boulevard, Wayside 3-1246. **LOS ANGELES:** 2244 East 37th Street, Kimball 6384. **MILWAUKEE:** 1717 E. Kane Place, Lakeside 2838. **NEW YORK CITY:** 122 East 42nd Street, Lexington 2-8260. **PHILADELPHIA:** 401 North Broad Street, Bell-Walnut 2-6997. **REDWOOD CITY, CALIF.:** Broadway and National, Emerson 6-3861. **WEST SPRINGFIELD, MASS.:** 1025 Elm Street, Springfield 2-1881. **EAST SYRACUSE, N. Y.:** 226 Roby Avenue, East Syracuse 366. **WICHITA:** 340 North St. Francis Street, Wichita 2-6971.

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California, office

YOU NEED THIS BOOK!

IF YOU BUY...USE...
OR SPECIFY SMALL PARTS

Here's one of the most up-to-date and complete booklets on practically all types of small metal parts. Gives you engineering specifications and vital data on application of:

Lock Washers	Snap Rings
Lock Nuts	C Washers
Spring Washers	Retaining Rings
Flat Washers	Flat Springs
Stampings	Coiled Springs
Welded Parts	Hose Clamps

You'll find this booklet a valuable addition to your technical library. It is crammed with sizes, facts and figures ... data on latest AN specifications ... information on how you can save your company time and money in the production of small parts.

This is just another part of Diamond G Service offered to industry by Garrett's, manufacturers of small parts. Whatever your needs—even though they may seem impossible to meet—call the Diamond G man. We think you'll be amazed. When a promise of quality, price or delivery is given by Garrett's—YOU ARE SURE OF SATISFACTION. Diamond G Service is based on turning the seemingly impossible into a regular reality.

DIAMOND G PRODUCTS
Manufactured by
GEORGE K. GARRETT CO., INC.
1421 Chestnut St., Phila., Pa.

GARRETT
MANUFACTURERS OF SMALL PARTS

it was equipped to build, and would build in quantity.

From this point, the author traces the problems and progress of the various divisions in getting into full scale production of military goods, and in developing new products to shorten hostilities. The engineering achievements that were made are truly astonishing: the first large scale production of pure metallic uranium, which required buying all the garbage cans in Bloomfield, N. J. for pots for the electrolytic process; a revolutionary axial-flow aviation gas turbine; gyroscope stablizing elements for tank guns, aircraft guns, and shipboard use; radar equipment; mobile power stations; and hundreds of other items.

There are no engineering facts in this book, for it is essentially, a story of achievement. But from it the reader will learn the most important fact of all—the genius and potentiality of American industry.

Handbook of Chemistry and Physics

CHARLES D. HODGMAN, *Editor in Chief. 2686 pages, 5 x 7½ in., 30th edition, Published by Chemical Rubber Publishing Co., 2310 Superior Ave., N. E., Cleveland, Ohio.* $6.

In the latest edition of this long-standing reference book, the general features and scheme of arrangement, which have received extensive endorsement in former editions, have been retained. The aim of this handbook is to present in condensed form as large an amount of accurate, reliable and up-to-date information in the fields of chemistry and physics as is consistent with convenience in form and the possibility of wide utility and distribution. A large proportion of the tables have been compiled especially for the handbook from authoritative collections of data and from current journals.

The mathematical section in the new edition has been modified by the substitution of a more convenient and more complete table of natural logarithms, and by some minor rearrangement of tabular material. To those interested in nuclear physics, one of the most useful changes is the replacement of several separate tables on isotopes and radioactivity by a recent single compilation listing the properties of all artificial and natural radioactive and stable isotopes. The growing importance of synthetic rubber is reflected by the addition of a new table giving a large range of physical properties of natural and synthetic rubber stocks.

The Handbook of Chemistry and Physics is divided into the following

about SPRINGS?

Illinois Coil Spring Company, Chicago, makes them right—and at reasonable cost. Regarded by an ever increasing number of manufacturers as the ideal source for high grade mechanical springs, all types and sizes—also clips, small stampings and wire forms. We'll design them for you or make them exactly to your specifications. Plant is large enough to handle big orders smoothly, compact enough to give prompt service on small orders and experimental work. Our steady growth is evidence that policy, price and production are RIGHT So why not call us in on that spring job?

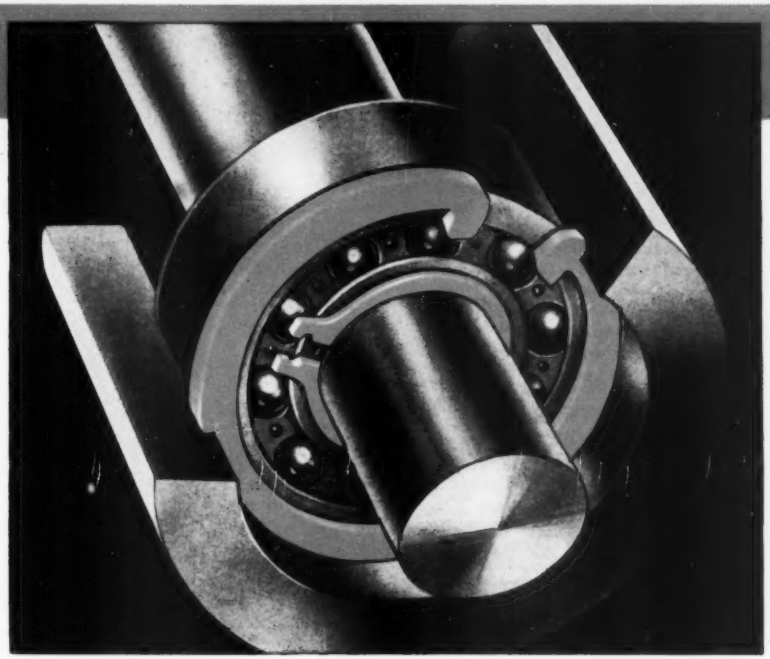
Sent On Request!

Interesting new bulletin "BRIEF GUIDE for SPRING BUYERS," tells in plain language what a good spring is and how to get it without excessive cost.

MR. _____
FIRM _____
STREET _____
CITY _____

(Mail to 2100 N. Major Ave., Chicago 39, Ill.)

•Save Time •Save Materials •Save Money!



Examine the designs of **all** your products and machines. No doubt you can use retaining rings on axles and in housings – not **only to save assembly time, but to save weight, parts and space.**

The use of these inexpensive yet efficient artificial shoulders is already widespread, and is increasing daily.

There are literally thousands of places in which redesigning for retaining rings can increase your profits and improve your products – uses ranging from heavy duty engines and drill presses to toys, gadgets and small parts of innumerable articles.

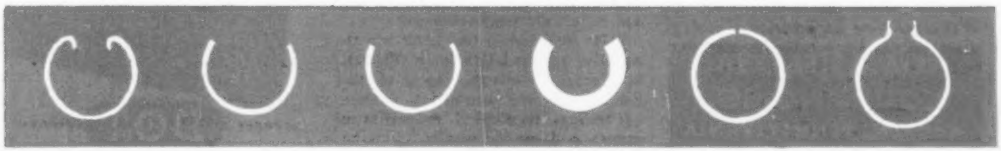
It's wasteful to cut down shafts to make shoulders. Redesign to groove smaller shafts and housings and use these high grade steel rings.

Let our engineers consult with you. Send for folders.

Don't pass up this opportunity to increase profits.

THE NATIONAL LOCK WASHER CO.

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN



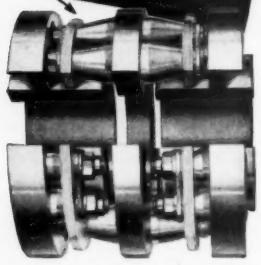
THOMAS
Flexible ALL METAL
COUPLINGS

Engineered to stand up on the toughest jobs, Thomas Flexible Couplings do not depend on springs, gears, rubber or grids to drive. All power is transmitted by direct pull.

The standard line of Thomas Couplings meets practically all requirements. But if unusual conditions exist we are equipped to engineer and build special couplings.

BACKLASH
FRICTION
WEAR and
CROSS-PULL
are eliminated
NO LUBRICATION
REQUIRED!

PATENTED
FLEXIBLE
DISCS



THE THOMAS PRINCIPLE
GUARANTEES PERFECT
BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT

Write for New Engineering Catalog

THOMAS FLEXIBLE
COUPLING CO.
WARREN, PENNSYLVANIA

general section: Mathematical tables; properties and physical constants; general chemical tables; specific gravity and properties of matter; heat; hygrometric and barometric tables; sound; electricity and magnetism; light quantities and units; and a large miscellaneous section which includes many useful physical and engineering tables.

ASTM Standards on Plastics

Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. 6 x 9 in., 610 pages. Fourth edition. $4.50.

Sponsored by the ASTM Committee D-20 on Plastics, this fourth edition of the ASTM Standards on Plastics is greatly amplified, giving the latest approved form of more than 100 specifications and tests which cover a wide range of plastics and related materials.

Specifications covering molding compounds include the following: Phenolic; polystyrene; cellulose acetate; vinylidene chloride; methacrylate; nylon injection; melamine-and urea-formaldehydes. Also given are requirements for cast methacrylate sheets and rods; laminated thermosetting materials; rubber and synthetic rubber compounds; machines and servicing units for tests at subnormal and supernormal temperatures; and nonrigid polyvinyl tubing; along with many others. Three specifications cover nonrigid plastics—vinyl chloride-acetate, vinyl chloride, and vinyl butyral; under radio applications are found phenolic laminated sheet, and round phenolic laminated tubing.

The 85 methods of test provide recognized standardization procedures for determining a wide range of properties of plastics. Indication of the type of test covered are given by the following: Accelerated weathering; arc resistance; bearing strength; compressive strength; density; diffusion of light; expansion; flammability; hardness; relative humidity; punching quality; softening point; surface irregularities; thermal linear expansion; tubes, both laminated and rigid; Young's modulus in flexure and many others.

There are 11 recommended practices including practices for accelerated weathering; impact resistance; molding specimens of amino plastics, phenolic materials, and phenolic materials for use in electrical tests; designation of numerical requirements in standards, and characteristics of standard carbon arc weathering unit.

Also included in this book is a descriptive nomenclature for plastics and standardized terms relating to plastics, conditioning and weathering, methods of testing, rheological properties of matter, and specific gravity.

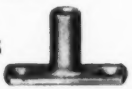
If you're looking for Special Fasteners...

in quantities suitable to volume production--Call upon United-Carr. Our

Design Engineers are available to work directly with yours--

to show you how to

★ CUT COSTS



★ SPEED PRODUCTION

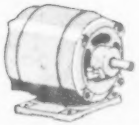
★ TURN OUT FINER FINISHED PRODUCTS

UNITED-CARR
FASTENER Corp.
CAMBRIDGE 42, MASSACHUSETTS

MAKERS OF DOT FASTENERS

NEW MICRO Precision Switch

rating — 1½ Horsepower Motor at 230 Volts a-c.



In the new Type "A" Switch, MICRO SWITCH offers a small, lightweight, accurate switch to handle the high current inrush required in the operation of solenoids, motors and tungsten lamps.

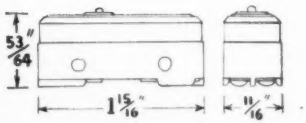
The MICRO Type "A" Switch rating—1½ H.P. motor 230 volts a-c; ¾ H.P. motor 115 volts a-c; 10 amperes, 125-250 volts a-c; tungsten lamp 10 amperes 125 volts a-c; and 75 amperes inrush capacity to 460 volts a-c.

If your design requires a small precise control switch which must take high current inrush throughout a long life . . . with no danger of welding or sticking . . . be sure you have all the facts on this new MICRO Type "A" Switch.

If your design calls for any kind of a small precision switch, MICRO SWITCH representatives can select from over 3900 variations of switches the one best suited to your needs. Call or write a MICRO SWITCH engineer at one of the offices listed below.

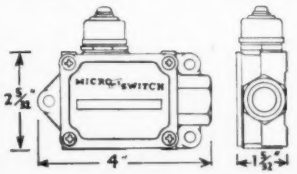
MICRO . . . first name in precision switches

New MICRO Type "A" Switch



This small switch will handle a 1½ H.P. motor at 230 volts a-c. It is available with five different types of actuators.

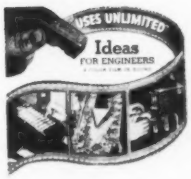
Sturdy Type "F" Die Cast Housing



This MICRO Type "F" die cast housing is designed for the high capacity Type "A" Switch. The synthetic rubber seal boot covers the operating plunger and resists the entrance of oil, moisture, dust, etc. Available in right and left hand designs.

"USES UNLIMITED"

A dramatic MICRO SWITCH 16 mm. sound motion picture in color, is available to industrial groups, training classes, schools and colleges. Running time, 35 minutes.



© 1949 First Industrial Corp.

MICRO SWITCH
A DIVISION OF FIRST INDUSTRIAL CORPORATION
FREEPORT, ILLINOIS, U. S. A.

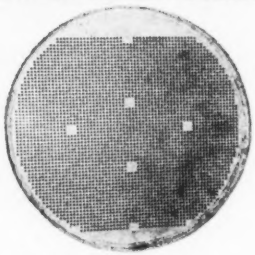
BRANCH OFFICES:
Chicago • New York • Boston • Cleveland • Los Angeles

SALES REPRESENTATIVES:
Portland • St. Louis • Dallas • Toronto

SMALL METAL TUBING (Max. O.D. 5/8")

MUST WITHSTAND PRESSURE AND HEAT IN

CONDENSERS
HEAT EXCHANGERS
HYDRAULIC
PRESSURE SYSTEMS



There's nothing like knowing—in advance—that *Superior* tubing possesses the inherent qualities of safety, endurance and reliability so necessary when the tubing is to be used to contain liquids or gases *under pressure*. Superior tubing in carbon and stainless steels is produced to respond excellently to bending, flaring, flanging, pulsating, etc.—made with relatively high endurance characteristics that eliminate early tube failure.

With Superior tubing you get *all* of these qualities—

. . . Straight, clean, bright tubing—for smooth flow of media.
. . . Square cut and deburred ends—for ease of fabrication.
. . . Maximum, uniform softness—for ease of bending and flaring.
. . . Standardization under current ASTM specifications.

We welcome the opportunity to furnish you with full information regarding your particular tubing requirements. Bulletin #31, listing analyses available and commercial tolerances, will be sent upon request.

We will be glad to see you at our Booth #1829 at the National Metal Exposition.

Superior

THE BIG NAME IN SMALL TUBING (.010" TO ½" O.D. MAX.)

SUPERIOR TUBE COMPANY

2012 GERMANTOWN AVENUE, NORRISTOWN, PA.

For Superior tubing on the West Coast, call PACIFIC TUBE COMPANY, 5710 Smithway Street, Los Angeles 22, Cal., ANgeles 2-2151

OUR READERS SAY

Management Needs Engineers

To the Editor:

Please accept my compliments for an excellent editorial in the September issue of PRODUCT ENGINEERING.

As one who has worked in former years for several large companies, I think the point about "management being long on demands but devoid of ideas" is excellent. Now that I am faced with managerial decisions of my own, I have tried to keep in mind the ideas that you expressed so well in this editorial.—R. B. WEREY, *President Conoflow Corp.*

Ed.—Thank you. It is always a pleasure to receive sincere commendation.

Metal Coatings for Plastics

To the Editor:

Will you please furnish us with additional information on the application of metal coatings for plastics as outlined in the "Highlights" section of your September issue.

—F. D. DOLAN, *Vice President American Floor Surfacing Machine Co.*

Ed.—Our mention of metal coatings on plastics was of a very general nature. However, we can briefly outline a few uses of the process here.

The vacuum process for plating the metal has been used for both decorative and engineering applications. Included in this is the coating of mica with silver or paper with zinc. Such coated components are claimed to be self-healing when material is overheated. This process, however, cannot be applied to plastics which are either high in plasticizers or moisture. Metal spraying has been used successfully on wood, glass and mica surfaces not only in the electrical insulator field but also in the development of printed circuits. The metal spraying process for printed circuits is used on steatite base plates. We hope this information will be helpful to you.

Midget Electronic Tube

To the Editor:

In your "Highlight" section of PRODUCT ENGINEERING for October 1948 is a description of a new small electronic tube which may be used in

need gears?

you'll find them easier, faster if you...

...reach for your SWEET'S

When you need specific information on materials, finishes or parts, reach for your Sweet's File for Product Designers (the big orange file). It contains 169 manufacturers' catalogs full of useful information on thousands of products . . . from absorbers—shock, to zinc. Cross indexing speeds finding.

If Sweet's File for Product Designers is not available in your office, make request immediately for application form. Files are distributed FREE to qualified organizations and individuals.

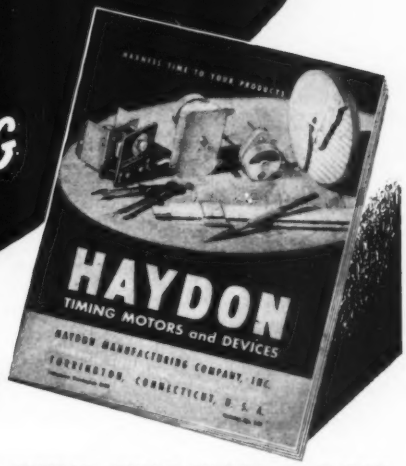
Sweet's

CATALOG SERVICE

for easier, faster selection of products

119 W. 40th ST., NEW YORK 18, N. Y.

A NEW TIMING CATALOG



featuring

TIMING MOTORS • REPEAT CYCLE TIMERS • CLOCK MOVEMENTS • RESET TIMERS • ELAPSED TIME INDICATORS • TIME DELAY RELAYS • INTERVAL TIMERS TIME CONTROL-CLOCKS • SPECIAL TIMING DEVICES

Haydon offers a new 20-page, 2 color catalog on synchronous timing motors, timing devices and clock movements. The catalog contains photographs, dimension drawings and complete specifications for all units. Specifications for 9 different timing motor series include size, mounting, speed, voltages, frequencies, shafts, wattage, torque, standard features and special variations. Complete listings of models and range of variations for all timers and clock movements are also given.

Write today for this new Haydon catalog. A copy is yours for the asking. If you wish, a Haydon representative will deliver a copy to your desk and discuss with you your timing requirements.

3113 ELM STREET, TORRINGTON, CONNECTICUT

HAYDON

MANUFACTURING COMPANY, INC.

TORRINGTON, CONNECTICUT

HARNESS TIME TO YOUR PRODUCTS

SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

Char-Lynn ALUMINUM
DIE CASTINGS
By a special Char-Lynn process, heavy section castings can be produced without porosity. Fast, accurate Reed-Prentice machines, manned by able craftsmen, turn out castings of quality. You are assured of permanence of dimension and shape . . . good surface finish . . . time and money saved in your finishing department. Write or phone for engineering consultation and estimates.
LARGEST IN THE UPPER MIDWEST . . .
Up to 6 pound capacity
CHAR-LYNN COMPANY
2869 26th AVENUE SOUTH • MINNEAPOLIS 6, MINN. • DUpont 2354

Sewall GEARS
CUSTOM MADE
For EVERY NEED
For best results, get in touch with Sewall engineers while your product is still on the drawing board. Close tolerances are efficiently maintained in the production of racks... sprockets... spur... spiral... bevel... Zerol bevel... worm gears. We furnish prompt estimates on any quantity.
E. B. SEWALL MANUFACTURING CO.
696 Glendale St. St. Paul 4, Minnesota

conjunction with a magnet to detect relative motion. Would you please supply us with further information about this equipment.—J. R. HOWARD, *Ethyl Corporation, Research Laboratories, Detroit, Mich.*

Ed.—This miniature tube is a development of the Eastman Kodak Co., Rochester, N. Y. We suggest that you contact Mr. R. G. Tarrington of the Research Laboratories.

Patents and the Engineer

To the Editor:

I have read with considerable interest your article "Patents and the Engineer" which was included in two parts in your June and July issues.

In this company, the patent work is handled by periodic patent conferences of the engineering management, by members of a firm of Patent Attorneys and by a Patent Assistant. The latter changes periodically, and we shall be using your article to inform and guide our new Patent Assistants.

—RICHARD W. TOELKEN, *Aircraft-Marine Products Inc.*

Sleeve Bearings

To the Editor:

We were extremely interested in your article on sleeve bearings in the November issue of PRODUCT ENGINEERING. The mass of information which you were able to uncover was amazing. Perhaps during the writing of this study you found a good text on ball and roller bearings. If so, would you please recommend to us such literature.

We consider your magazine the best in our Engineering Department—congratulations.—T. F. SPAEKMAN, *Director of Engineering, Chefford Master Mfg. Co. Inc.*

Ed.—We were glad to know that the article you referred to was helpful, because we did spend much time on gathering that material.

I am sure that the engineering department of any of the ball and roller bearing manufacturers would have good suggestions on outstanding design literature. A book that was helpful to us was "Roller Bearings", by R. K. Allan. This is an English publication put out by Sir Issac Pitman and Sons, Limited.

Sponge Rubber

To the Editor:

In the "Highlights" section of the August issue of Product Engineering, mention is made of a particular kind

One Relay or 100,000 . . .

CLARE RELAYS

Are *Each* Carefully Tested Against Your Specifications

Clare's Chief Inspector reports only to the president. He is responsible for the most important thing in our business . . . that the Clare Relay you order is *exactly* the Clare Relay you receive.

Whether your order is for one Clare Relay or 100,000 . . . every single relay is 100% inspected and tested against your specifications.

Mechanical adjustment, electrical characteristics, physical appearance and construction . . . every detail is gone over by experts specially trained in Clare's precise requirements. Not a single relay is sealed for packing until it conforms in every way with the highest standards of relay performance.

Such infinite capacity for taking pains is a basic reason for Clare's leadership in the industrial relay field. It accentuates the value of Clare's superior design, precise manufacture and unusual understanding of difficult relay design problems.

Clare sales engineers, fully experienced in every type of relay requirement, are located in principal cities for your convenience. If you have a relay problem that seems really tough . . . look to Clare. Enjoy the services of this organization whose entire business is devoted to making sure that you have the relay which best meets *your* needs.

Look in your classified telephone directory . . . or write: C. P. Clare & Co., 4719 West Sunnyside Ave., Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

Every Single CLARE Relay Must Pass These Tests

For Mechanical Adjustment

1. Contact Pressures (Make or Break)
2. Contact Follow, or Wipe
3. Sequence of Make and Break Contacts
4. Correct Airline
5. Residual Setting
6. Spring Straightness

Physical Inspection

1. Plating (For Marks or Scratches)
2. Proper Insulation
3. Condition of Insulation (No cracks, etc.)
4. Tapping of Screw Holes
5. Spring Thickness
6. Coil Data on Label and Condition of Label

Electrical Inspection

1. Coil Resistance
2. Coil Breakdown
3. Pileup Breakdown
4. Operation (as specified)
5. Direction of Winding
6. Test for Shorted Turns

All Clare Relays Are Packed Immediately Following Inspection

CLARE RELAYS

First in the Industrial Field

If you use an Ace *hard rubber* comb, you have a materials testing lab right in your pocket, for a good comb has to meet specs that are *tough!*

It's light and thin, but shows amazing strength in taming knotty hair and surviving 6-ft. falls. It gets covered with oil, doused regularly in hot water and sterilizing chemicals, yet a genuine hard rubber comb lasts for years.

It's a good example of fabricating, too. It starts as a molding. The teeth are machine-cut. Finally, a series of grinding and polishing operations give it that smooth, satiny feel.

Best for nearly 100 years, there still is no other material as good for combs. It shows you why Ace hard rubber is preferred in thousands of parts for machines, appliances, automobiles, furniture, etc. Other important Ace plastics also available.

Write for helpful Ace Handbook

ACE
Since 1851
HARD RUBBER and OTHER IMPORTANT PLASTICS
AMERICAN HARD RUBBER COMPANY
11 MERCER STREET • NEW YORK 13, N. Y.

of sponge rubber. I would appreciate further information on the properties and molding characteristics of this material, or reference to a source of such information. —J. S. MOTT,
Engineering Section,
General Electric Co.

Ed. Information on this material, known commercially as Spon, can be obtained from the Commonwealth Engineering Co., Dayton, Ohio.

Elastomeric Material

To the Editor:

It was with interest that I noted an item in the "Highlights" section of the August issue on airway relief maps made of elastomeric material. If additional information is available on this subject, I would appreciate more details. —PAUL E. LAFRANCE,
Swarthmore, Pa.

Ed.—Complete details can be obtained from Parrot Plastics Inc., Belleville, N. J.

Alloyed Magnet

To the Editor:

We would appreciate additional information on the new magnet made of silver, alloyed with aluminum and magnesium mentioned in the "Highlights" section of the August issue of PRODUCT ENGINEERING.

IRVEN M. DEAN,
Kenffel & Esser Co.

Ed.—Information on this may be obtained from General Electric Company, Metallurgy Div., Chemical Dept., Pittsfield, Mass.

Ultrasonic Testing Devices

To the Editor:

We use a number of grey iron and aluminums and castings in our products. Quite often, these castings contain hidden cracks, pits and other imperfections which only show up after machining or in final assembly.

Our Inspection Department would like to know if there is any new equipment available that would enable them to discover these defects before machining. We seem to recall seeing in PRODUCT ENGINEERING an article which mentioned an electronic tester for checking castings, and we would appreciate any information you may have on the subject. —V. F. FRYE,
Chief Engineer,
U. S. Slicing Machine Co., Inc.

Ed.—It sounds as if you can find the solution to your problem with an ultrasonic testing device made by General Motors. The instrument is called the

THE MODERN ELECTRIC RESISTANCE WELDED STEEL TUBING...

Michigan WELDED STEEL TUBING

ROUND

¼" to 4" O.D. 9 to 22 gauge

SQUARE-RECTANGULAR

½" to 2" 20 gauge 1" to 2¾", 14, 16, 18 gauge

Standard Sizes

Tube Diameter O.D. Size	Maximum Wall BWG Decimal	Maximum Wall BWG Gauge	Minimum Wall BWG Decimal	Minimum Wall BWG Gauge
¼	.049	18	.028	22
⅜	.065	16	.028	24
½	.083	14	.022	24
⅝	.095	13	.022	24
¾	.095	13	.022	24
⅞	.095	13	.022	24
1	.095	13	.022	22
1⅛	.095	13	.028	22
1¼	.095	13	.028	22
1⅜	.095	13	.028	22
1½	.120	11	.028	20
1⅝	.120	11	.035	20
1¾	.120	11	.035	20
1⅞	.148	9	.035	20
2	.148	9	.035	20
2⅛	.148	9	.035	20
2¼	.120	11	.035	20
2⅜	.148	9	.035	20
2½	.120	11	.035	18
2⅝	.148	9	.035	18
2¾	.148	9	.049	18
2⅞	.148	9	.049	18
3	.148	9	.049	18
3⅛	.148	9	.049	18
3¼	.148	9	.049	18
3⅜	.148	9	.049	16
3½	.148	9	.049	16
3⅝	.148	9	.065	16
3¾	.148	9	.065	16
3⅞	.148	9	.065	16
4	.148	9	.065	

Can be **BENT** also . . .

FLANGED, EXPANDED, TAPERED, DEPRESSED BEADED, EXPAND BEADED, ROLLED, EXTERNAL UPSET, INTERNAL UPSET, SPUN CLOSED, FORGED, BEVEL FLANGED, FLATTENED, SWAGED, FLUTED

Engineering advice and technical help in the selection of tubing best suited to your needs. Address your inquiries to:

Michigan STEEL TUBE PRODUCTS CO.

More Than 30 Years in the Business

9450 BUFFALO STREET • DETROIT 12, MICHIGAN

FACTORIES: DETROIT, MICHIGAN • SHELBY, OHIO

DISTRIBUTORS: Steel Sales Corp., Detroit, Chicago, St. Louis, Milwaukee, Indianapolis and Minneapolis—Miller Steel Co., Inc., Hillside, N. J.—C. L. Hyland, Dayton, Ohio—Dirks & Company, Portland, Oregon—James J. Shannon, Milton, Mass.—Service Steel Co., Los Angeles, Calif.—American Tubular & Steel Products Co., Pittsburgh, Pa.—Strong, Carlisle & Hammond Co., Cleveland, Ohio—Drummond, McCall & Co., Ltd., Toronto, Canada.

Free Folder!

--tells how to finish ZINC OR CADMIUM for better CORROSION RESISTANCE ...PAINT BASE

Eye Appeal

If your product uses zinc or cadmium in any form, find out now about Iridite . . . the chemical dip finish that boosts corrosion resistance . . . provides a paint base that defies peeling, flaking, chipping . . . brightens zinc, keeps it bright and free from stains. Mail coupon today.

Free

Please send me illustrated folder and sample panels of Iridite

NAME_____

COMPANY_____

ADDRESS_____

PRODUCTS_____

ALLIED RESEARCH PRODUCTS, INC.

4004 EAST MONUMENT STREET

BALTIMORE 5, MD.

Sonigage, and information about it can be obtained from the General Motors Research Laboratory, Detroit, Mich.

Resin-Bonded Paper

To the Editor:

Your September issue carries a note about resin-bonded paper for reinforcing plywood. We would appreciate additional information.

—L. C. TOLLESON,
Mechanical Research,
Union Bleachery.

Ed.—Information can be obtained from Kimberly-Clark Corp., Kennah, Wis.

Australian Report

To the Editor:

Will you kindly inform me how I can obtain a copy of the Australian report on bearing materials, as mentioned in the August issue of PRODUCT ENGINEERING.

—H. W. BOESSENKOOL,
General Plate Div.,
—Metals & Controls Corp.

Ed.—A copy of this report can be had by writing to the Tribo Physics section of the Australian Council for Scientific and Industrial Research, Melbourne, Australia.

Molded Wheels

To the Editor:

Will you kindly send us more information on the molded member wheels mentioned in "Highlights" section of your September issue.

—J. L. COLE,
Purchasing Agent,
Wak Industries.

Ed.—The member wheels you mentioned are manufactured by the F. B. Redington Co., Chicago, Ill., from whom you may obtain additional information.

German Scientists

To the Editor:

Sometime ago I noticed an article in Product Engineering describing the situation and use of German scientific personnel in U. S. industry. I would appreciate it if you would tell me the issue in which this appeared.

—O. T. SYGALL

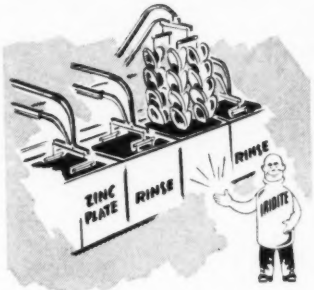
Ed.—Contained in the News Section of our January 1948 issue. German scientists are given positions in U. S. industry through the operations of the Office of Technical Service, Department of Commerce, Washington, D. C.

Now--a one dip

IRIDITE

bright finish for

AUTOMATIC ZINC PLATING



COMMON CHEMICAL ADDITION ELIMINATES CAUSTIC RINSE—PERMITS AMAZING LOW COST

The one-dip Iridite Bright treatment for standard automatic zinc plating machines has been proved successful and is now being used in production runs.

RESISTS CORROSION—PROTECTS FROM STAIN

This amazingly low cost protective and brightening process produces a shining stain-free surface with good corrosion resistance . . . utilizing only the normal number of tanks after the zinc plating operation: rinse, Iridite, rinse.

SIMPLE TO OPERATE—NO BLEACHING DIP

This special one-dip Iridite Bright is a non-electrolytic chemical solution . . . operates at 80 to 85° F . . . with no specially trained personnel . . . equally adaptable to bulk plating of parts. Eliminates need for second or bleaching dip.

Whatever your problem in finishing zinc or cadmium — there's an Iridite to do the job. For details, write—wire—or 'phone.

ALLIED RESEARCH PRODUCTS, INC.

4004 EAST MONUMENT STREET

BALTIMORE 5, MD.

THE GOOD RIGHT HAND OF INDUSTRY

Off in a Jiffy...

Your customer makes speed changes quickly with the two-piece QD Sheave.

Worthington QD Sheave—Original Tapered Cone-Grip Sheave. Easy to Get On—Easy to Get Off—Yet Always Tight on the Shaft. The Quality-Built Sheave That Makes Alignment Easy—for Longer Belt Life.

The rim comes off easily—the pull-up bolts are used as jack screws to break the tapered fit between rim and hub.

Installing is just as easy. The light-weight split hub is locked in place first . . . then the tapered-bore rim is pulled up over the tapered-cone hub.

And the QD *stays tight* on the shaft. The cone-friction grip on the hub produces a positive press fit on the shaft. The QD clamps the shaft tighter than any other sheave on the market.

For Balanced Drive Performance

Specify Worthington Multi-V-Drives, with QD Sheaves and Worthington-Goodyear EC V-Belts. Each strand in the belt carries its equal share of the belt load, as each belt carries its full share of the drive load. (Goodyear EC Cord or Steel Cable V-Belts are used exclusively in Worthington Multi-V-Drives.)

Complete Range of Stock Sizes—Prompt Shipment

853 listed stock sizes in "A", "B", "C" and "D" sections, fhp to 200 hp . . . 332 listed stock sizes of EC Cord V-belts. Send coupon for latest Worthington QD Sheave bulletin.

WORTHINGTON

MERCHANDISING DIVISION

The Good Right Hand of Industry

PUMPS: centrifugal, power, rotary, steam
COMPRESSORS: horizontal, radial, vertical
POWER TRANSMISSION: sheaves, V-belts, variable speed drives

Worthington Pump and Machinery Corp.
Merchandising Division, Dept. P857
Harrison, New Jersey

☐ Send latest bulletin on Worthington Multi-V-Drives.

Name.....

Company.....

Address.....

50-57

This Copper Stud is a Tough Part to Make...

Tough? Yes, impossible to make in any practical way except by cold heading. Scovill turns it out in highest quality, fast and at low cost. Examples like this of the art of cold heading demonstrate for your benefit a wide range of possibilities in the hands of Scovill craftsmen.

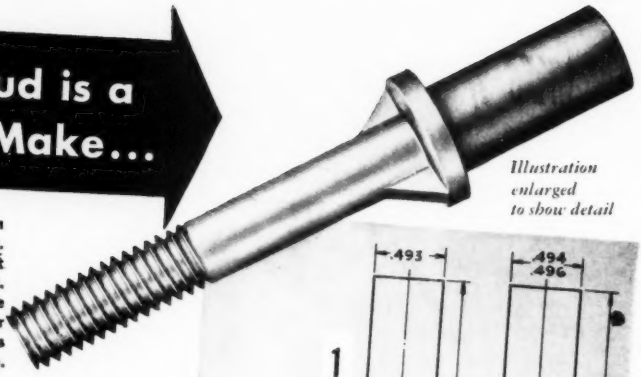
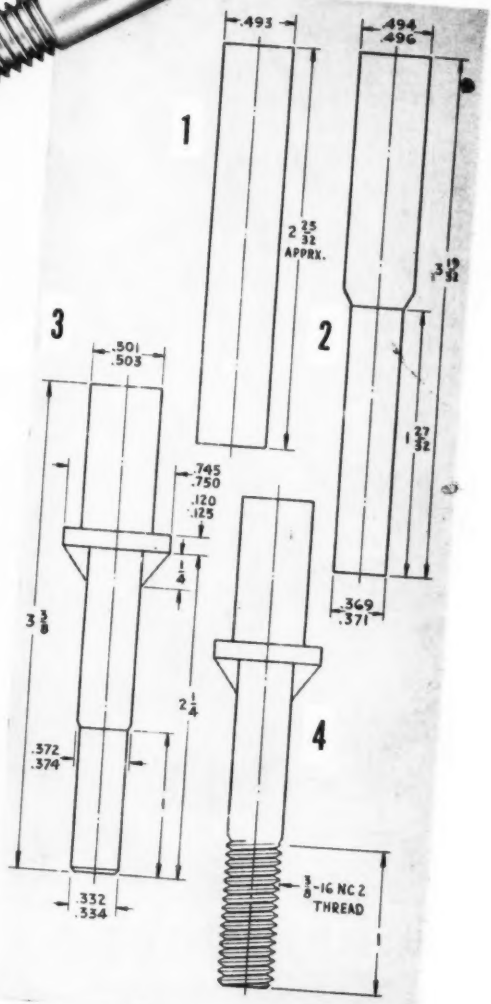


Illustration enlarged to show detail



Intricate Shapes *Are* Practical

Note the sharp-cornered, accurately placed and perfectly formed *lugs* under the flange. The accomplishment of this essential feature automatically restricts its manufacture to cold heading.

Cold heading technique permits the formation of the comparatively small body diameter and a large head by extrusion. This results in a tremendous saving of metal.

Consider These Inherent Advantages

Cold heading conserves metal. Close tolerances are held—fewer operations are necessary. Fast, economical production is assured. The product is of highest quality and finish, of greater strength, the tools for producing it are a minor item of expense.

Scovill Experience Opens New Possibilities for Savings

Take another look, now, at your parts or fasteners that are not made by cold heading. Perhaps cold heading offers savings, together with highest quality.

And, in particular, talk over cold heading possibilities with us on new parts or fasteners you need *before* definitely putting them down on your drawing board.

Send now for "A Guide to the Profitable Use of Cold Heading." Here, clearly explained, are the advantages and limitations in designing fasteners and component parts for the cold heading process.

We will be glad to work out your requirements with you. Note below the Scovill Industrial Fastener Representative conveniently located near you.

Special Cold Headed Parts • Phillips Recessed Head Screws
Clutch Recessed Head Screws • Washer Screw Assemblies (Sems)
Tapping Screws • Standard Machine Screws

INDUSTRIAL FASTENER SALES
WATERVILLE DIVISION

SCOVILL MANUFACTURING CO.
Waterville 48, Connecticut

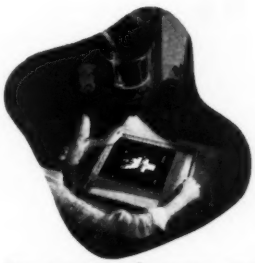
New York, Chrysler Building • Detroit, 6460 Kercheval Avenue • Chicago, 222 West Adams Street • Los Angeles, 2627 South Soto Street
Syracuse, Syracuse-Kemper Insurance Building • Cleveland, Terminal Tower Building • San Francisco, 434 Brannan Street

4 new photographic papers... provide unique advantages with standard reproduction equipment

For use in direct process and blueprint machines... *Kodagraph Autopositive Paper.* The *first* low-cost photographic intermediate paper . . . the *first* that produces positive copies directly—without the negative step . . . the *first* that can be exposed in your present machine and processed under normal lighting. With it you can preserve new drawings . . . restore old, soiled ones . . . obtain intermediates with dense photographic black lines on a clear translucent base—fast and durable in subsequent print-making . . . "photo-lasting" in your files.

For use in contact photocopy machines . . . *Kodagraph Contact Paper.* Sparkling, more legible results—and lower costs—with this all-new, inexpensive paper. It reproduces your work in dense photographic blacks, brilliant whites. Processing is easier, surer . . . thanks to a non-curling base . . . extremely wide latitude . . . amazing uniformity from sheet to sheet, package to package.

Kodagraph Reproduction Papers

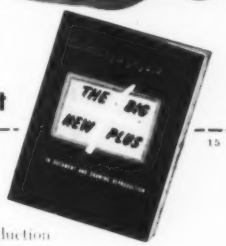


For use in enlargers, projection printers, process cameras . . . 2 *Kodagraph Projection Papers.* You have this choice, now, whenever there's call for change-of-scale prints: *Kodagraph Projection Paper* . . . if you prefer plentiful safe-light illumination . . . and ample time to dodge prints. *Kodagraph Fast Projection Paper* . . . if maximum printing speed is preferred. Both papers are available in several thicknesses. Thus, you can produce reference copies, translucent intermediates, or durable ledger sheets. Whatever your choice, you always get sharp, flat-lying prints.

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

"Kodak" is a trade-mark

Still another "plus"... Kodagraph Developer and Kodagraph Fixer . . . for convenient use with all Kodagraph papers . . . packaged to yield 1 or 5 gallons of solution. Learn in detail how the Kodagraph line provides unique advantages with your *present reproduction equipment.* Write today for "The Big New Plus."



Mail coupon for FREE booklet

Eastman Kodak Company
Industrial Photographic Division
Rochester 4, N. Y.

Please send me a copy of "The Big New Plus"—your booklet about Kodagraph Reproduction Papers. I have ☐ direct process ☐ blueprint ☐ contact printing ☐ projection equipment.

Name _____ (please print)

Department _____

Company _____

Street _____

City _____

State _____

Kodak

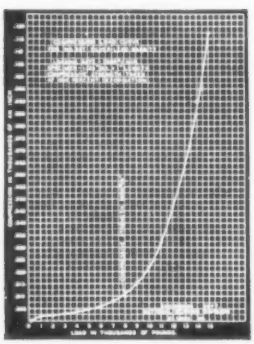
"*Let's Specify* **N-B-M #397 SILVER BABBITT**

. . . we'll get good service and save money!"

Yes, this engineer has found by experience that N-B-M #397 Silver Babbitt can be specified on all types of bearing applications that require long, dependable service . . . *and at 30% to 40% less cost per pound than tin-base babbitt!*

N-B-M Silver Babbitt has all the necessary characteristics that spell trouble-free bearing application. It's easy to bond; embeds dirt and grit, even at room temperature; resists corrosion and squeezing out.

Find out more about money-saving, long-wearing N-B-M Silver Babbitt. Every product Designer or Plant Engineer should have a copy of the N-B-M Silver Babbitt folder, complete with physical characteristics and engineering briefs. Write for your copy today!



N-B-M . . . Serving Industry with Better Products . . . Better Service

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4930 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

ASK STOKES

...if you need to know more about Industrial Tabletting

IN powdered metals and in ceramics Industrial Tabletting is growing rapidly as a high-speed low-cost manufacturing process.

Stokes is a source—perhaps we may say *the* source—for authoritative information on the subject . . . for documented information on procedure . . . for the best in equipment.

We have a dozen machines specially designed for these fields. We build them test them, prove them. We invent, design and adapt for new purposes. Our chemists, physicists, mechanical and electrical engineers, take *your* problems through our semi-plant-scale laboratories and bring you proved procedures and samples with cost estimates.

Sometimes they prove you shouldn't do it by industrial tabletting. In any case you get the facts . . . fortified by 50 years of intimate association with manufacturers in the Metal, Chemical, Ceramic, Electrical, and Food Processing fields.

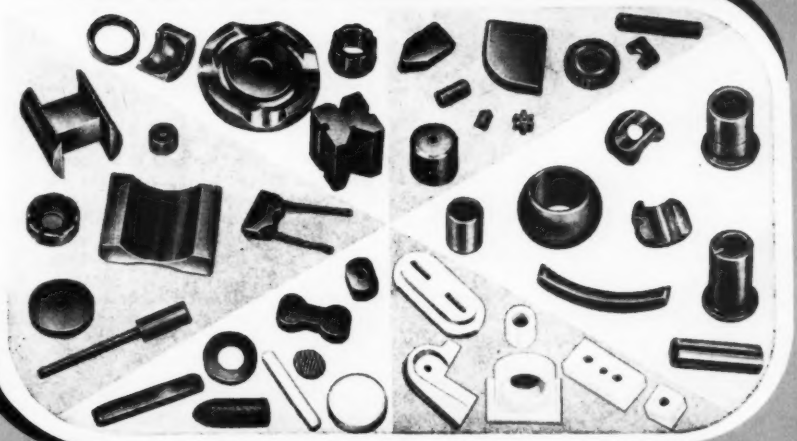
We've learned a lot in 50 years of that sort of thing, and we've made notes—a library-full—which is our source for the information we use in helping solve your problems.

F. J. Stokes Machine Co., 5900 Tabor Rd., Phila. 20., Pa.

Stokes makes Vacuum and Special Processing equipment, High Vacuum Pumps and Gages, Pharmaceutical equipment, Industrial Tabletting and Powder Metal Presses, Plastics Molding Presses, Water Stills and Special Machinery.

A Few Typical Industrial Tabletted Products

- Machine Parts
- Cemented Carbides
- Porous Bearings
- Ceramics
- Chemicals
- Electrical Products



STOKES KNOWS HOW

"Difficult"* Shapes

in MADISON-KIPP *aluminum die castings*

* The "Difficult" used in the headline is a polite word as far as tool room parlance is concerned for the subject part, but the designer had good reasons for every dimension line.

This vibrator frame is "unstraight" and the radii "start from the factory chimney", but it fits the hand, and function is perfect. It is a good example of how and when to utilize the advantages of the Madison-Kipp die casting process.

When you have die casting requirements, please contact our home office in Madison, Wisconsin.

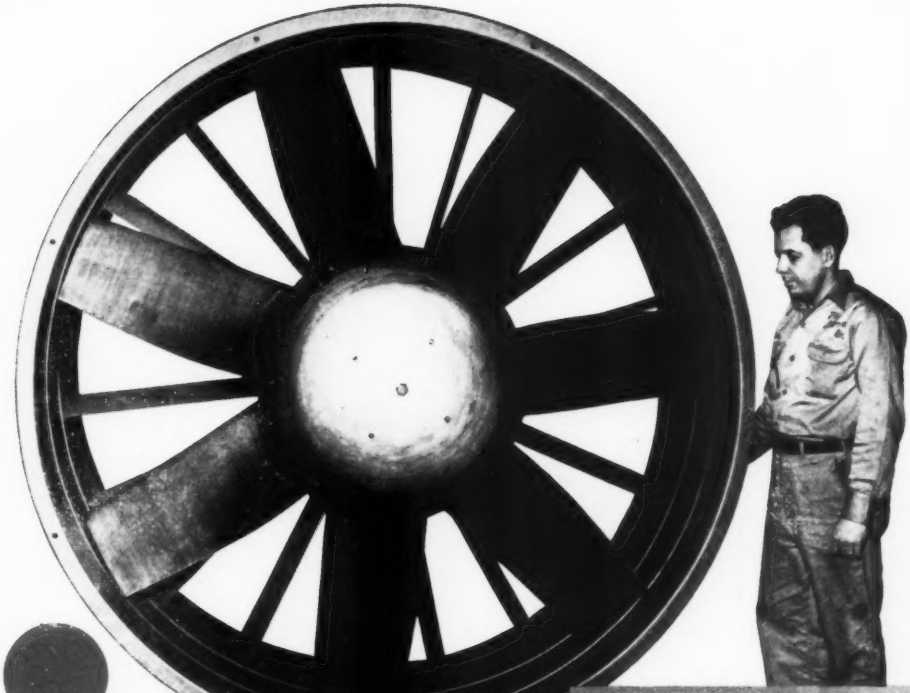
MADISON-KIPP CORPORATION

206 Waubesa Street, Madison 10, Wis., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marias, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS



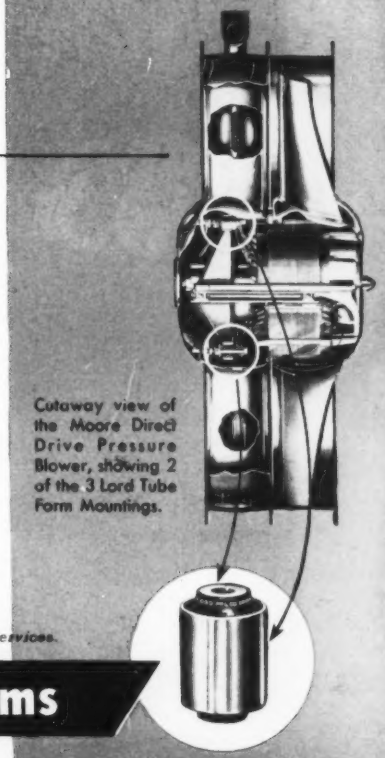
big *but quiet...*

with a LORD vibration control system

Moore Fans and Blowers move lots of air—up to 125,000 cu. ft. per minute—in a variety of industrial cooling and ventilating applications. Smooth, quiet operation is desirable in all of these applications—to avoid distracting workers, and to help assure years of trouble-free service.

The Moore Company, 544 Westport Ave., Kansas City, Mo., solved the problem of vibration and vibratory noise by mounting the motor on three Lord Tube Form Mountings. The bonded rubber mountings minimize noise transfer which would detract from employee morale and efficiency . . . prevent motor vibration from being transferred to the housing . . . assure smooth performance and long life.

Does your product have moving parts . . . or is it exposed to external vibrating forces? If the answer is yes—whether you make delicate recording instruments or massive machinery—a Lord Vibration Control System will increase your product's efficiency, durability, and customer appeal. Consult a Lord engineer. There is no obligation.



Cutaway view of the Moore Direct Drive Pressure Blower, showing 2 of the 3 Lord Tube Form Mountings.

Write for Bulletin 900 today. It describes the complete line of Lord products and services.

LORD Vibration Control Systems

LORD MANUFACTURING COMPANY • ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp. Ltd.

Steel-Weld FABRICATION

These Steel-Weld Fabricated heavy machine parts are typical of work turned out in the Mahon plant for many customers representative of a cross section of heavy industry in the United States. You also, will find the Mahon Company an excellent source for welded Steel in any form . . . a source equipped to provide complete machining service on any welded steel products or parts. Mahon's staff of design engineering experts, backed by craftsmen highly skilled in the latest techniques in the welding art, are your assurance of a better, smoother appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 11, MICHIGAN

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON

600,000 ~~400,000~~ CASTINGS FROM THIS DIE-

and not a mark on its face

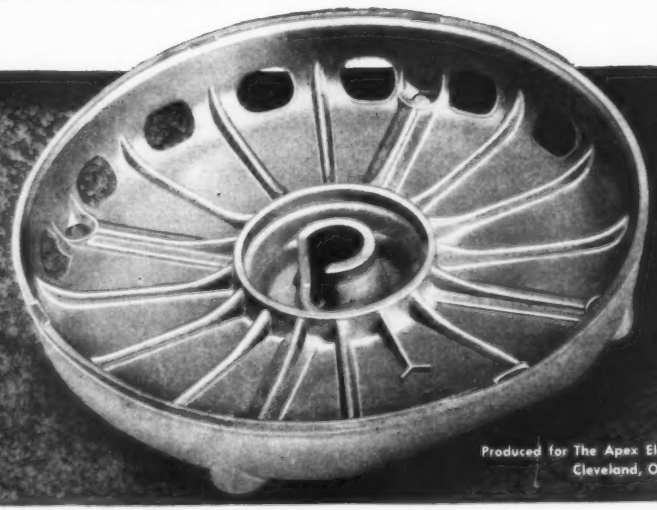
CASE HISTORIES FROM MT. VERNON FILES

Here at Mount Vernon, we are proud of our long-lived dies that "stand the gaff", exceed normal life expectancy despite the severe punishment of continuous operation. The one pictured has duplicated the casting shown more than 600,000 times—and it is still in use, showing no check marks.

Die casting affords two outstanding production economies: (1) rapid production; (2) reduced machining and finishing.

Both advantages are fundamental factors in establishing lower unit costs. But the degree to which savings may be realized depends upon the quality of the workmanship in making the dies and the care with which they are used. Dies that retain their accuracy for longer periods—yield clean, flawless castings day in and day out—quickly write off initial costs, and reduce ultimate costs appreciably.

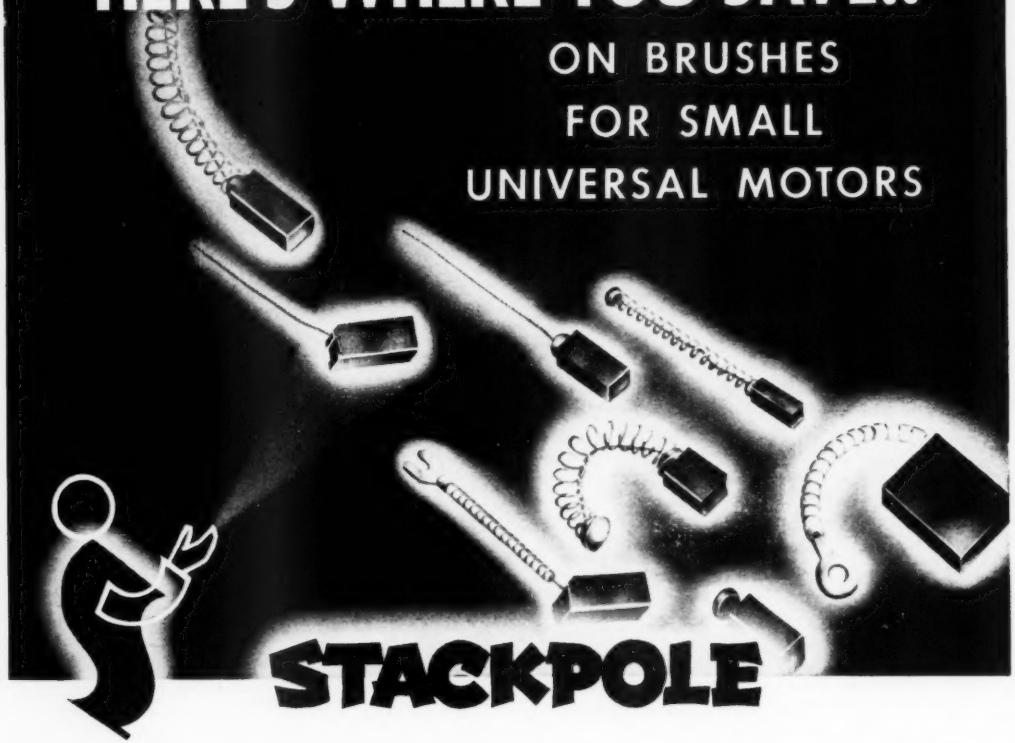
If you have not already profited by the economies to be gained from die casting, consult with us. We are confident that, with our comprehensive experience, skills and modern facilities, we can show you the way to increased output at lower cost.



Produced for The Apex Electrical Mfg. Co. Cleveland, Ohio

HERE'S WHERE YOU SAVE..

ON BRUSHES FOR SMALL UNIVERSAL MOTORS



Money and Commutator Saving Brushes for AC-DC Motors

Write for fractional

H. P. BRUSH USER'S GUIDE

This 44-page book is a helpful guide for evaluating brush materials and choosing the one best suited for your particular motor and application. Write on company stationery for a copy.

Without exception, leading makers of small AC-DC motors who have used Stackpole grades of brushes *have reported materially longer brush life and less commutator wear!*

Although some new Stackpole brush grades have high specific resistance, their contact drop is such that both motor speed and torque are essentially the same as when conventional electrographitic brush grades are used. Mechanical strength is exceptionally high—a particularly desirable characteristic in small universal motor brushes. Also, various Stackpole brush grades have shown excellent results on AC-DC motors having undercut mica as well as those with the flush mica commutator bar type of insulation.

TEST SAMPLES TO QUANTITY USERS . . .

The one way to tell about motor brushes is to try them on your own equipment, under actual operating conditions. We're so confident that Stackpole Brushes will show you a real saving that, providing you are a quantity user of small universal motor brushes, we'll gladly send samples for test. Give full details of your motor rating, application, and brush data.

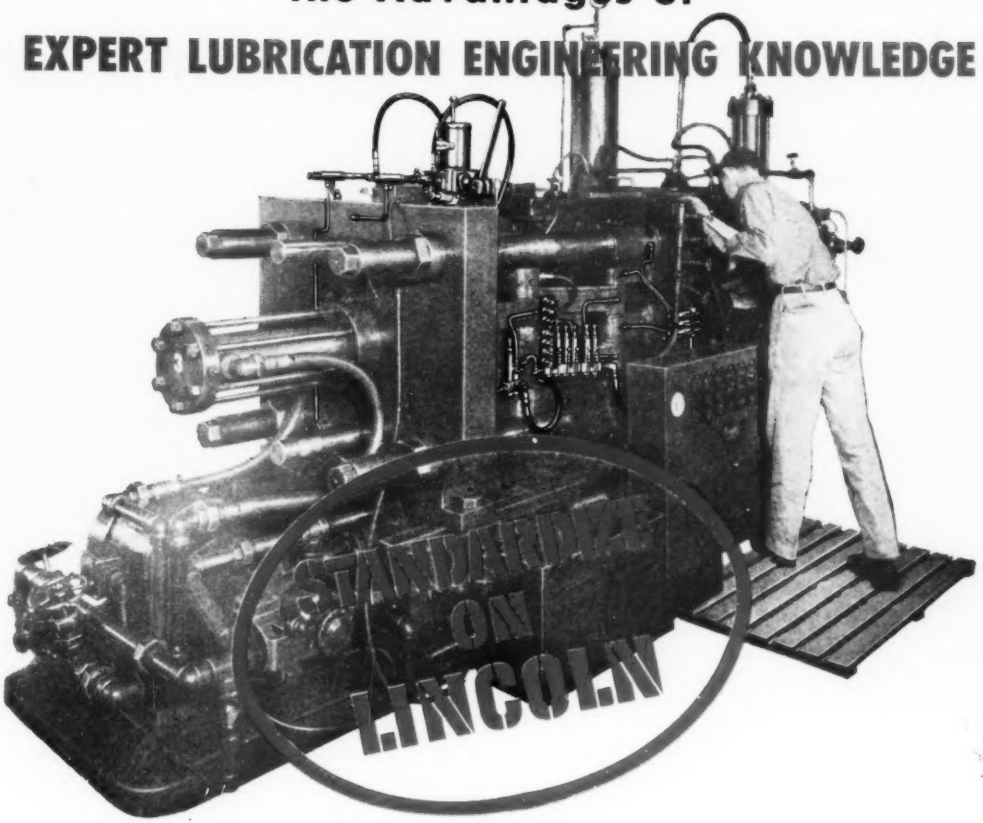
STACKPOLE CARBON COMPANY • ST. MARYS, PA.

"EVERYTHING IN CARBON BUT DIAMONDS"

MOLDED CARBON, GRAPHITE AND POWDERED METAL SPECIALTIES . . . *Write for details on any type*

BATTERY CARBONS • BEARINGS • BRAZING FURNACE BOATS • BRUSHES • CARBON, GRAPHITE AND METAL CONTACTS • CARBON VOLTAGE REGULATOR DISCS • CHEMICAL CARBONS • CLUTCH RINGS • DASH POT PLUNGERS • POWER TUBE ANODES • RESISTANCE WELDING AND BRAZING TIPS • SEAL RINGS • SPECIAL MOLDS AND DIES • TROLLEY AND PANTOGRAPH SHOES • WATER HEATER & PASTEURIZATION ELECTRODES • WELDING CARBONS, ETC.

assure the users of your machines the Advantages of EXPERT LUBRICATION ENGINEERING KNOWLEDGE



Avoid the penalties of inefficient methods of lubrication—High Cost of Labor . . . Low Rate of Production . . . Inferior Quality . . . Unnecessary Down-Time . . . Costly Repair Parts . . . Excessive Power Consumption . . . All imposed by inadequate or improper lubrication when expert lubrication engineering knowledge is not available.

Rely on a centralized system of lubrication engineered to suit the requirements of your particular machine. Standardize on a Lincoln Centro-Matic Lubricating System.

Today, exacting operating demands for higher efficiency plus lower maintenance costs create new responsibilities for the designing engineer. Lincoln's lubrication experience can help. Call your local wholesale distributor or contact any of the Lincoln Sales and Service Offices listed below. Bulletin 801, "Lincoln Centro-Matic System for Mass Lubrication" will be sent upon request.

SALES AND SERVICE OFFICES

BOSTON—H. G. Davis, Inc.—Kenmore 5176
BRIDGEPORT—H. G. Davis, Inc.—Bridgeport 5-8160
CHICAGO—Lincoln Engineering Co. of Ill.—Calumet 5-6022
CLEVELAND—Lincoln Lubricating Systems, Inc.—Express 4334
DETROIT—Lincoln Engineering Co.—Madison 3484
EAST ORANGE—Lincoln Lubricating Systems, Inc.—Orange 3-3188
FORT WORTH—Fritz Keller—2-1345
LOS ANGELES—Lincoln Engineering Co. of Calif.—Richmond 0151
MILWAUKEE—Lincoln Equipment Service—Division 1191
NEW YORK—Lincoln Lubricating Systems, Inc.—Trafalgar 7-7900
OAKLAND—Lincoln Engineering Co. of Calif.—Higate 6130
PHILADELPHIA—Lincoln Engineering Co.—Locust 4-3877
PITTSBURGH—Lincoln Engineering Co.—Montrose 1444
PORTLAND—Pioneer Equipment Company—Lancaster 0488

• Apply The Right Lubricant • In The Right Quantity • At The Right Time

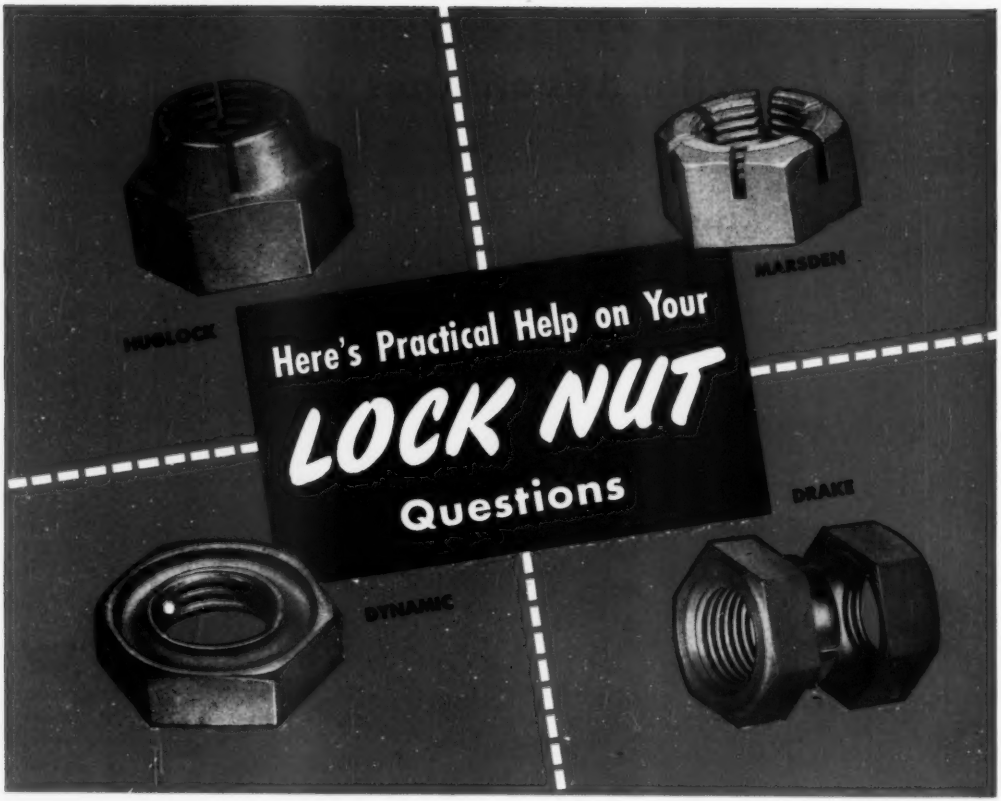
Lincoln is the originator of the Kleenseal Surface Check Grease Fitting—The modern fitting with the ball in the top.

T. M. LINCOLN and Trade Name Centro-Matic Reg. U. S. Pat. Off.

LINCOLN

Builders of complete Lubrication Systems for a quarter of a century

LINCOLN ENGINEERING COMPANY • 5701 NATURAL BRIDGE AVE., ST. LOUIS 20, MO.



Every problem of vibration and loosening of parts calls for careful study to find just the right answer. "National" engineers have encountered just about every type of problem, and our line of Lock Nuts is designed to meet an unusually wide range of requirements. The booklet illustrated here contains much useful data and should be helpful in determining type, size and cost of lock nuts for a given application. A copy will be sent on request.

Other "National" products:
HODELL CHAINS,
CHESTER HOISTS.

For heavy duty — National's "Drake" Lock Nut withstands severe stress, shock or vibration. A two-piece, positive lock for use on rugged, heavy equipment, where size and weight are not a factor.

To withstand shear only — National's "Dynamic" Lock Nut is a thin, lightweight nut with diaphragm lock, for use where clearance is a factor and where strains are in shear only.

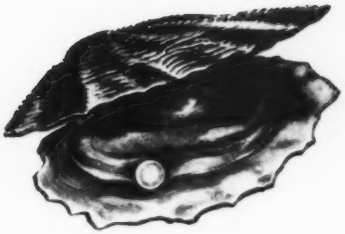
For shock-loading or vibration, even under heat, oil or moisture, National's "Huglock" Lock Nut is a one-piece, all-metal lock nut. Easily installed, it grips the bolt threads and maintains locking effect whether seated or not.

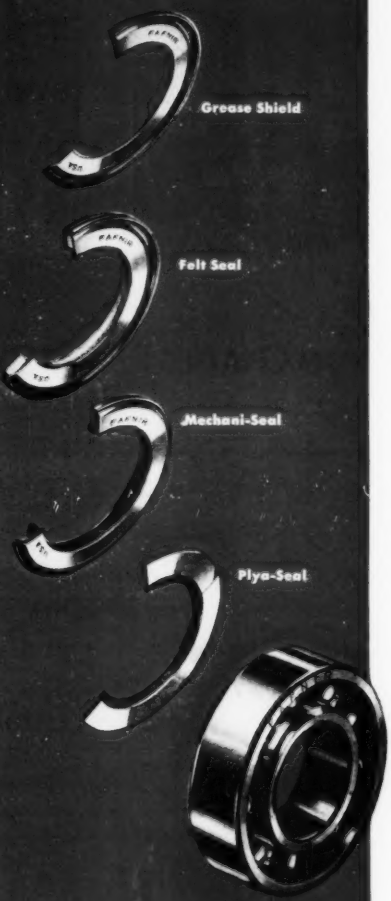
For effective, low-cost locking. National's "Marsden" Lock Nut is a one-piece, cantilever action type, easily applied, free running until seated. For the most complete line of standard and special fasteners, come to "National".

National
HEADED AND THREADED
PRODUCTS

THE NATIONAL SCREW & MFG. CO.
Cleveland 4, Ohio
Pacific Coast: **National Screw & Mfg. Co. of Cal.**
1649 18th Street, Santa Monica, Cal.

Only an oyster can make pearls out of GRIT





When an oyster yawns too wide and gets some grit in the works, it goes into the jewelry business... making pearls. But grit inside a ball bearing puts it out of business. And the conditions of an oyster's life are nothing to what a ball bearing has to put up with in construction machinery, airplanes and in textile mills and chemical plants. So devising "shells" for ball bearings to crawl into was a natural for Fafnir pioneering... beginning more than twenty years ago.

Survival of the "fittest"

In order for these seals and shields to keep lubricant *inside* the ball bearing and lock dirt *outside* they must be fitted to thousandths of an inch . . . yet the bearing must be left free-moving, unencumbered. And in the latest Fafnir development, the Plya-Seal, even this infinitesimal clearance has been abolished. It's a "wiping contact" yet the bearing's free as air. One of these bearings carries this evolution an interesting step further: it includes a grease chamber which provides lubrication for years and years of maintenance-free service. Today Fafnir-designed ball bearings can take almost any condition that industry throws at them . . . brine, steam pressure, desert heat and polar cold, dripping moisture and clouds of acid and alkali.

Need some ingenuity and interest?

Could be, there's no place in your machine for these Fafnir protected ball bearings. But there's certainly a place in your product planning for the kind of ingenuity and interest that produced all these variations on a basic theme to meet specific problems in various industries. That's the point... Fafnir's experience is not limited to just one or two industries but is industry-wide. The Fafnir Bearing Company, New Britain, Conn.

MOST COMPLETE LINE IN AMERICA

FAFNIR
BALL BEARINGS

What's Interesting About UNION CHAIN'S Raw Materials?

Union Chains for Every Application

Drive and Conveying Chains and Sprockets
- Bridge Chain
- Combination Malleable Iron and Steel Chain
- HB (hardened bearing) type chain
- BP (bar and pin) type chain

★

Finished Steel Roller Chains and Sprockets
- All manufacturer's standard, size ⅜ in. to 2½ in. pitch
- Single and Multiple Strands
- Extended Pitch Series in sizes 1¼ in. to 4 in. pitch

★

Silent Chain and Sprockets
- All sizes ⅜ in. to 1½ in. pitch

★

Flexible Couplings
- Roller chain type
- Silent chain type

Sprocket chain is essentially an assembly of Sidebars, Bushings, Rollers and Pins, fabricated from Strips, Bars, and Rounds of steel.

Since UNION manufactures all types of steel sprocket chain for the transmission of power and the mechanical handling of materials and **nothing else,** the specifications of every lot of Steel which UNION buys, are determined only by the desire to build the greatest ultimate service into the particular chain part for which it is required. This circumstance should be interesting to UNION'S present and future customers.

The Union Chain and Manufacturing Company

TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS

Sandusky, Ohio, U.S.A.

WHAT PROPERTIES DO YOU NEED IN A PLASTIC?

HEAT RESISTANCE? LOW MOISTURE ABSORPTION? TRANSPARENCY? COLOR? EASY MOLDING? LOW COST?

Koppers Polystyrene HAS THEM ALL

NEWEST in the line of Koppers Plastics is *Heat-Resisting Polystyrene 8*. This plastic will come through the scalding water of the automatic home dishwashing machine and retain its shape. *It is the only polystyrene that sells at the same low cost of regular polystyrene and still has the heat resistance to withstand scalding water.* No longer do you need to pay a premium price for heat resistance.

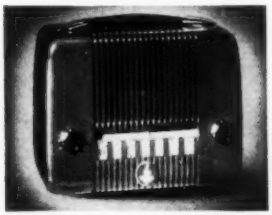
Koppers Polystyrene 8 has all the superior polystyrene advantages — crystal clarity, limitless colors, excellent electrical characteristics, negligible water absorption and low cost—and it will stand temperature 30° higher than regular polystyrene. It can be used for plastic kitchenware, tumblers, and electrical appliances. It will stand the concentrated heat of a radio power tube and finds many applications in decorative lamps and plastic wall tile.

Where easy moldability is all-important, Koppers Lubricated Polystyrene 3 offers the same low production costs and can be used for a tremendous variety of toys, display boxes and other items.

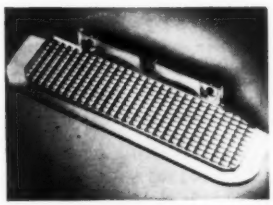
All of Koppers Polystyrenes sell at the same low price. Their light weight results in more pieces per pound. All scrap can be ground up and used again, keeping production costs at a minimum.

Koppers new and different commercial process for making polystyrene results in a product of high purity with the same physical characteristics maintained order after order. Send the coupon for new booklet.

KOPPERS COMPANY, INC.
Chemical Division · Pittsburgh 19, Pa.



Emerson portable radio cabinet molded from Koppers Polystyrene. Superior properties of Koppers Polystyrene result in more perfect cabinets per day and lower costs. Molded by Worcester Molded Plastics, Worcester, Mass.



Frigidaire Light Deflector for the inside of a refrigerator. Koppers Polystyrene was chosen for its transparency, light-diffusing properties and low water absorption. Molded by Wolverine Plastics for Michigan Molded Plastics.

Nite-Gard Nursery Light. Color, translucence and low cost made Koppers Polystyrene 3 a good choice for this night light molded by All Plastics Corporation, Avon-by-the-sea, New Jersey.

SEND FOR FREE BOOKLET

KOPPERS

Koppers Company, Inc.
Chemical Division, Dept. PE1
Pittsburgh 19, Pa.

Please send me your new booklet on Koppers plastics.

Name.....

Company.....

Position.....

Address.....

Koppers Plastics

*POLYSTYRENE *ETHYL CELLULOSE *CELLULOSE ACETATE

SERVICE CONDITIONS	TYPE OF PACKING		
	LEATHER	SYNTHETIC RUBBER HOMOGENEOUS	SYNTHETIC RUBBER FABRICATED
Oil	G	G	G
Air	G	G	G
Water	G	G	G
Oxygen	G	G	X
Steam			G
Some Solvents			G
Mild Acids			
Mild Caustic			
Resistance to Hea			F.
Resistance to Co			F.
Rotary Motion			
Reciprocating Mot			
Metal finishes (Mi			
Types of Metal			
Back support clearance			
Resistance to cold flo			
Friction (coefficient)			
Resistance to Abrasion			
Pressures, p.s.i. (Max.)			
*Chrome-plated steel and desired hard, sm th surfa			

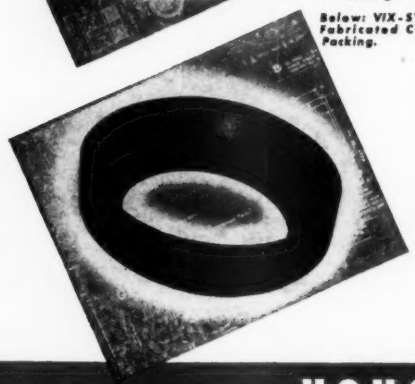
AIR
X=DO NOT RECOMMEND

G=GOOD
P=POOR

This may help you answer- "WHAT PACKING TO USE?"

Upper photo: VIX-SYN Homogeneous "V" Packing.

Below: VIX-SYN Fabricated Cup Packing.

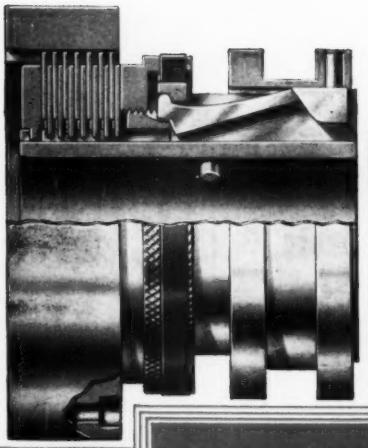


THAT'S an important question—one which must be answered correctly if your hydraulic or pneumatic devices are to function properly.

There are no positive rules—if there were, it would be easier. No two installations are exactly alike, but there are general rules which every design engineer should know . . . such information as where to use, or not to use, various types of packings, including leather and synthetic rubber. We supply both, and will make an impartial recommendation, based on your particular requirements.

As a general guide—but not an over-all rigid rule—we have reprinted a recent **HOUGHTON LINE** article containing a table showing what may be expected from each type of packing. A hint of that table is shown above. If you would like a copy, please write Hydraulic Department, E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Phila., Pa.

HOUGHTON'S VIM LEATHER and VIX-SYN PACKINGS



MAXITORQ

keeps Good Company !

THE MAXITORQ Floating Disc Clutch was designed to solve certain power transmission problems, especially those formerly encountered in automatic machine tool operation. As evidence that MAXITORQ design has proven successful we show the new Double End Tool Rotating Chucking Machine, manufactured by New Britain-Gridley Machine Division.

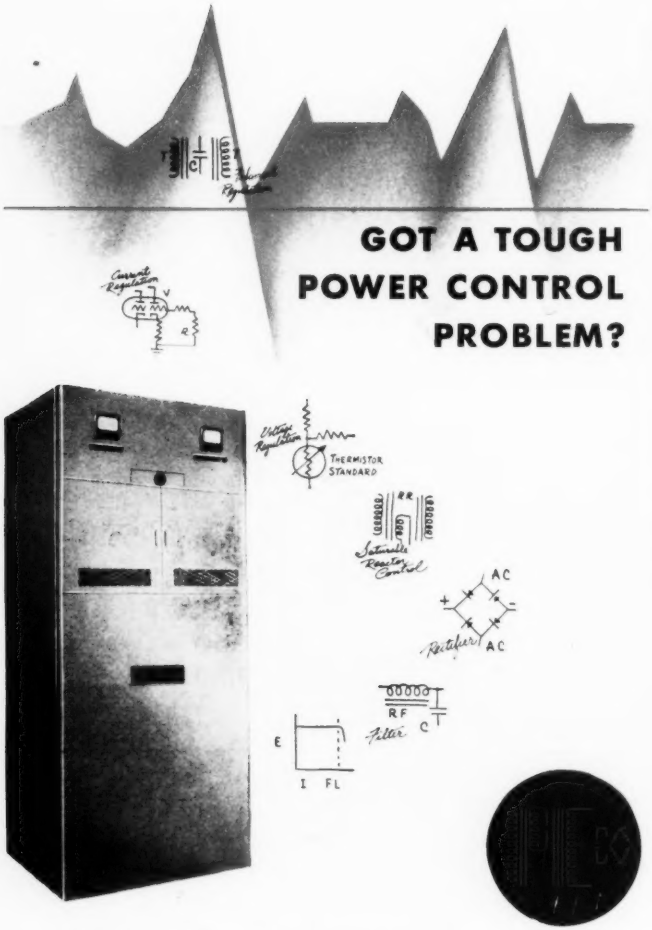
Normally two single clutches are used in this model . . . one to control feed motions, the other for control of the rapid transverse. When threading is done, at either or both ends of the machine, one double clutch serves each spindle.

May we suggest that Designers and Manufacturers of machine tools, and other machinery, ask for our detailed bulletin. It contains information you need . . . about the clutch you can use . . . profitably.

Send for Catalog No. PE1

ICJ48

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT



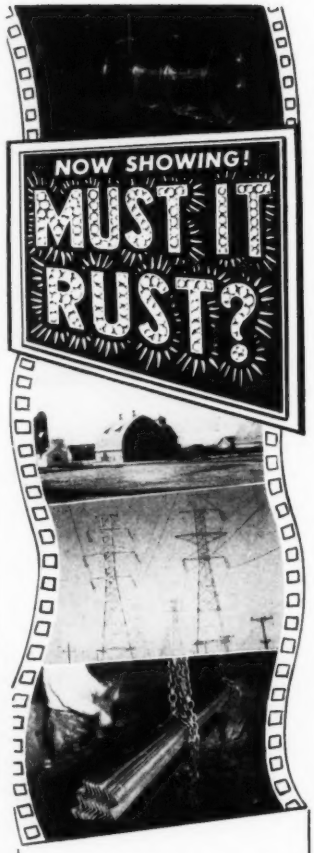
GOT A TOUGH POWER CONTROL PROBLEM?

If you're up against a tough power control problem . . . one that requires really fine accuracy in the regulation of current and voltage . . . chances are you'll find the answers here at Power Equipment Company. PEco, you know, has specialized in controlled rectifiers since 1935 . . . has pioneered in the development of many unusual types of equipments having the precise electrical characteristics required by a wide variety of exacting applications. So next time you have a problem involving control of electrical power, why not take advantage of this background of experience? An illustrated booklet describing PEco research, engineering and production facilities is yours for the asking. Write for Bulletin No. 848.

POWER EQUIPMENT

Battery Chargers ☆ Battery Eliminators ☆ D.C. Power Supply Units ☆ Regulated Exciters ☆ Voltage Stabilizers ☆ and other Special Communications Equipment

55 ANTOINETTE STREET / DETROIT 2, MICHIGAN

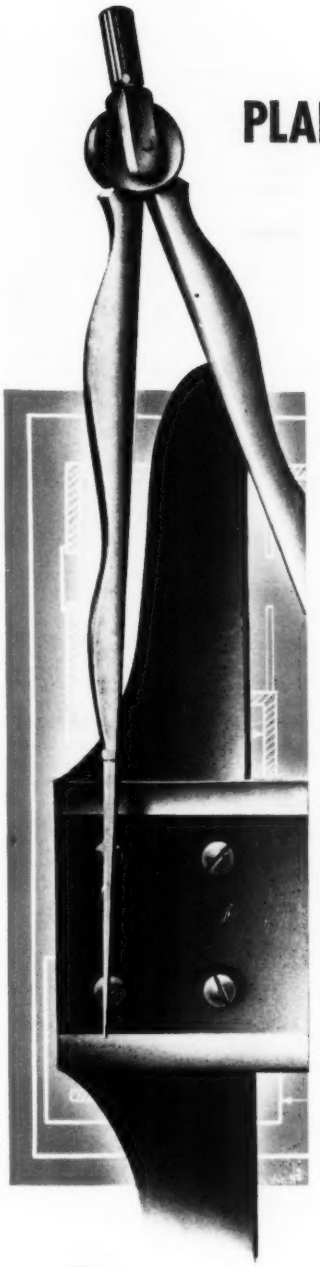


"MUST IT RUST?" A three billion dollar question that is dramatically answered in our 16 mm sound motion picture. This educational film is one that interests both consumer and producer—and everyone who is concerned with the problems of rust and corrosion should see it.

A print of this film will be gladly loaned—

Regarding availability of this 25-minute sound film in 16 mm size, for showing to your personnel, or to any group in your community, write, The Secretary, American Hot Dip Galvanizers Association, Inc., First National Bank Building, Pittsburgh, Pa.

hot-dip GALVANIZING

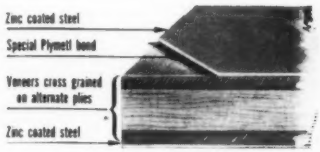


PLAN WITH *Plymetl*

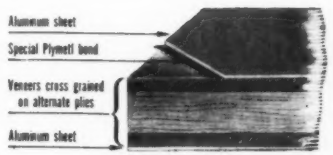
MAKES BETTER PRODUCTS POSSIBLE

Plymetl combines the light weight and rigidity of plywood with the strength of metal. Through 25 years of performance, Plymetl has proved its versatility, durability and dependability. When the War created shortages in supplies of critical metals Plymetl received still greater attention and wider use. Here Plymetl's performance in military equipment proved its worth as a basic structural material. For many applications Plymetl is unsurpassed. Where your product design requires a flat smooth surfaced material of unusual strength and light weight, a material unaffected by moisture and mold and fungi — and rust resistant — SPECIFY PLYMETL. A few of the more widely used types of Plymetl are described and diagramed below.

PLYMETL VE and EVE — A plywood plaque with zinc-coated steel sheet permanently bonded by an exclusive Haskelite method to one (VE) or both faces (EVE). Plymetl panels may be obtained in a range of thicknesses and sizes to suit specific applications. Simple wood- or-metal working tools will fabricate Plymetl.

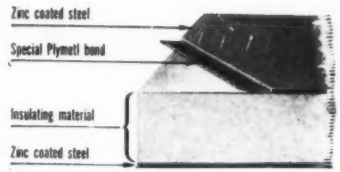


PLYMETL VU and UVU — A plywood plaque with aluminum sheet permanently bonded to one (VU) or both faces (UVU). The great strength and light weight factors of plywood are combined with the light weight of aluminum. Plymetl may be formed to certain curvatures.



PLYMETL ESE — A panel of insulating material with metal sheet permanently bonded to both faces (ESE).

Other types of core materials may be used to make varied kinds of Plymetl. To these cores, metal faces of monel metal, porcelain enamel steel, and stainless steel can be bonded. A core material may be faced with one type of metal on one side and another type on the other side. On all Plymetl panels, the metal faces provide an ideal surface for finishing.



Write for complete data on Plymetl, and bulletin SC45 which gives details on other types of Haskelite materials. Let Plymetl and Haskelite engineers help you design and build products that look better . . . sell better . . . and perform better.

HASKELITE

Dept. PE, GRAND RAPIDS 2, MICHIGAN

New York Chicago Detroit St. Louis Los Angeles Philadelphia
Canada: Railway & Power Engineering Corporation, Ltd.

6 times THE POWER OF ORDINARY SOLENOID VALVES

GENERAL CONTROLS

K-10 SERIES

ELECTRO-MAGNETIC LEVER VALVES

CONTROLS: LIGHT AND HEAVY OILS, AIR, WATER, GAS, STEAM, REFRIGERANTS, etc. Suitable for pressures up to 1000 pounds and temperatures up to 400° F.

SIX TIMES THE POWER of ordinary solenoids assures high seating pressure and overcomes the blocking effect of viscous fluids, such as heavy fuel oil. Adequate power of solenoid insures positive operation. Normally closed or open types available.

Internal valve assembly can be removed for cleaning and inspection if necessary. Two-wire –A.C. or D.C.–current failure–packless construction–bronze body–stainless steel and bronze internal parts–soft seats available.

FOR COMPLETE SPECIFICATIONS *request new Catalog.*

GENERAL CONTROLS

Manufacturers of Automatic Pressure, Temperature & Flow Controls

FACTORY BRANCHES: Birmingham (3), Boston (16), Chicago (5), Cleveland (15), Dallas (2), Denver (10), Detroit (8), Glendale (1), Houston (2), Kansas City (2), New York (17), Philadelphia (40), Pittsburgh (22), San Francisco (7), Seattle (1), Oklahoma City (1) • **DISTRIBUTORS IN PRINCIPAL CITIES**

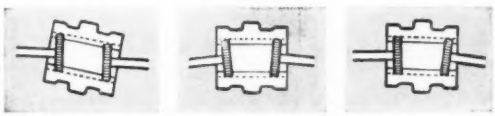
This

Metal-to-Metal Seal says "STOP" to Moisture, Dust and Grit!

That's why FAST'S COUPLINGS Give *Continuous* Service!

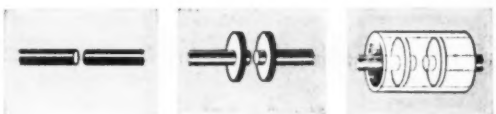
FAST'S self-aligning Couplings are completely free of perishable parts. They're all-steel throughout. At the vital spot shown above, this important feature is achieved through an *exclusive* "rocking bearing." This bearing is exclusive in providing a positive *metal-to-metal* seal that guards the load-carrying oil against troublesome moisture, dust and grit. The bearing is also exclusive in its correctly engineered position which allows *freedom of movement* to compensate for misalignment because its spherical base has the same axis as the hub spline faces. No perishable packing rings are used. There's nothing to wear, nothing to fail. Result: *uninterrupted* power transmission for all your installations!

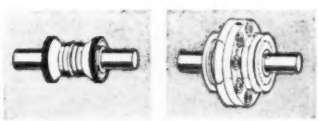
We have a complete line of couplings for immediate delivery. No matter which type of Fast's Couplings you buy, you get the benefits of years of top engineering experience, Koppers' high standard of workmanship and unexcelled coupling service which assures you of spare parts no matter how old your couplings may be. That means longer machine life, lower upkeep costs, minimum shutdown losses! Koppers Co., Inc., Fast's Coupling Dept., 271 Scott St., Baltimore 3, Md.



Compensate For All Misalignment

The floating sleeve takes a neutral position. All forms of misalignment are compensated for between the lubricated faces of the splines, equally divided between driving and driven members. The entire assembly revolves as one unit.





Simple As A-B-C

Fast's self-aligning Couplings are amazingly simple for the important job they handle. A splined hub on each shaft end. A sleeve with internal splines to mesh. Oil in the sleeve, kept between the splines by centrifugal force, carries the load between the splines.

K KOPPERS

FAST'S *self-aligning* COUPLINGS

SEND FOR FREE CATALOG giving detailed descriptions, engineering drawings, dimension and capacity tables and typical installation photographs for the many types of Fast's Couplings. Fill out this coupon and mail it to: Koppers Co., Inc., Fast's Coupling Dept., 271 Scott St., Baltimore 3, Md.

Name..... Position.....

Company.....

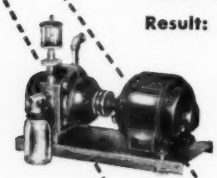
Street..... City..... State.....

VACUUM
SPEEDS CHUCKING . . .
another problem solved with
GAST ROTARY PUMPS

HOW TO HOLD ODD-SHAPED PIECES IN SPEED LATHE

Problem: Find a way to cut chucking time — and boost productive capacity — on a high-speed lathe used for polishing odd-shaped pieces.

Solution: A Gast Rotary Vacuum Pump (Model 20FF60) supplies vacuum for positive chucking through hollow spindle with rotary joint. Using a 1 h.p. direct-drive motor, pump rating is 17 c.f.m. — vacuum up to 27 inches.



Result: Chucking and set-up time is cut — productive time is increased. Thus, through keen engineering insight, another manufacturer improves his product with Gast Rotary Vacuum Pumps as components.

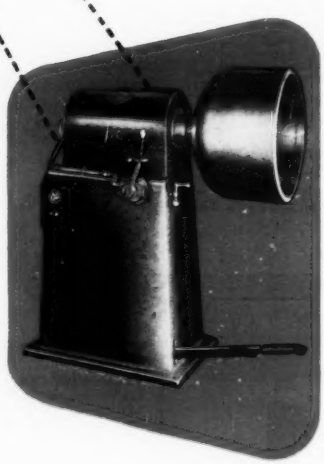
Lathe Manufacturer's name on request.

Perhaps you'll never face a problem just like this . . . yet Gast Rotary Units may solve other problems you'll have tomorrow!

Over 200 different variations of basic Gast units now serve as original equipment on scores of products. In totally *unrelated* fields — from automotive repair to chemical processing — Gast Rotary Air Motors, Vacuum Pumps and Compressors are helping improve performance, increase safety, and lower costs.

As an executive concerned with product design and improvement, you'll want to know more about Gast Rotary Units. If you have a specific problem, write us the details. We'll gladly cooperate with engineering help. Ask for your copy of our Idea-Catalog, too.

Remember —
"Air may be your Answer."



WRITE TODAY!
Request your copy of Gast's IDEA-CATALOG

GAST ROTARY — AIR MOTORS · COMPRESSORS · VACUUM PUMPS
(TO ONE H.P.) (TO 55 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

PAGE
Stainless Steel
WIRE

● ROUND

FLAT

OR

SHAPED

"Page for Wire— Especially Stainless"

Remember that the next time you are looking for a responsible source for stainless steel wire. Wire has always been the business of PAGE. And ever since its earliest development, PAGE has been working with stainless.

Whatever problem you may have involving wire—

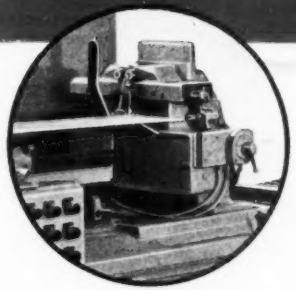
Get in touch with Page!

ACCO
Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Pittsburgh, Philadelphia, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE
In Business for Your Safety

Grinds both SPLINES and GEARS

Handles Work up to 48" Long . . .



For grinding involute gears and splines this machine can be equipped with the Geargrind Involute Trimmer. This has the capacity to true wheel from 32 to 4 diametral pitch.

● On this combination machine the work reciprocates past the grinding wheel, which automatically feeds down each time the work reverses. Grinding continues on one tooth space until a predetermined size is reached, after which the dresser moves into position for trueing the grinding wheel. All operations are automatic.

After the wheel is dressed the operator finish grinds in the conventional manner, indexing automatically from tooth to tooth.

Grinding is 3 to 4 times faster than by any previous machine of comparable capacity, due to 1), reduction of total number of indices required, 2), less carriage travel due to short roughing stroke and 3), cycling control which prevents a slowing of the machine cycle. This also permits one man to operate more than one machine.

CAPACITY—SG-10x48A

Between Centers	Up to 48"
Spline OD	1" to 6"
Max. swing	12½"
Teeth	4 to 120
Face width	Up to 34"

Features—

Double column support for grinding wheel head.
Automatic, adjustable grinding wheel feed.
Automatic wheel feed for trueing.
Automatically cushioned trueing position.
Automatic lubrication of ways.
Axial grinding wheel spindle adjustment.
Work table speeds up to 70 ft. per minute.
Control panel, with counters to adjust grinding cycle, interlocking safety features, very accessible mountings of push buttons and other controls.
Long base eliminates work table overhang. New way guards.
Simplified stroke adjustment.
Adjustable work arbor supports facilitate loading.
Recessed dogs and stops, for operator's safety.

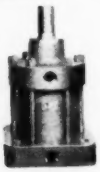
The GEAR GRINDING MACHINE COMPANY
DETROIT 11, MICH. U.S.A.

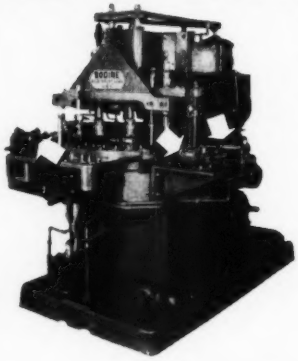
HERE'S HOW

T-J SAVES LABOR

ON THOUSANDS OF JOBS FOR INDUSTRY!

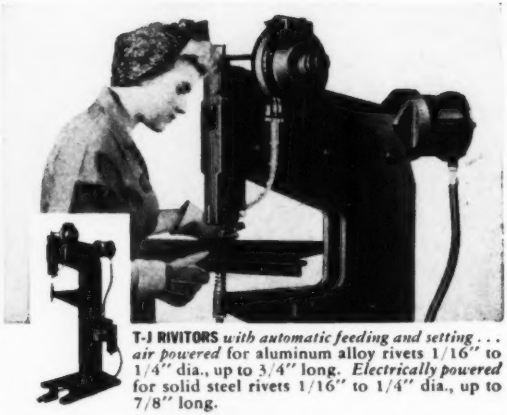
T-J HYDRAULIC CYLINDERS *simplify machines* . . . save time and labor on jobs where pushing, pulling or lifting is needed . . . 100 lb. or 50,000 lb. Shown here — a shell loading press with T-J Cylinders.





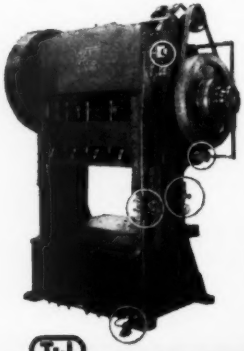
T-J AIR CYLINDERS *do push-pull-lift jobs* . . . 100 lb. to 12,000 lb. . . . wide range of styles, sizes and strokes. Shown here — Automatic Drilling and Threading Machine with T-J Cylinders.

T-J CLINCHORS *set clinch nuts 3 to 5 times faster* in automotive body panels, door locks, other products. Fully automatic—controlled by foot pedal.



T-J RIVITORS *with automatic feeding and setting . . . air powered* for aluminum alloy rivets 1/16" to 1/4" dia., up to 3/4" long. *Electrically powered* for solid steel rivets 1/16" to 1/4" dia., up to 7/8" long.

T-J AIR CONTROLS *provide accurate, automatic control* for presses, brakes, other machines and equipment . . . designed for air cylinders in semi-automatic or automatic cycles.

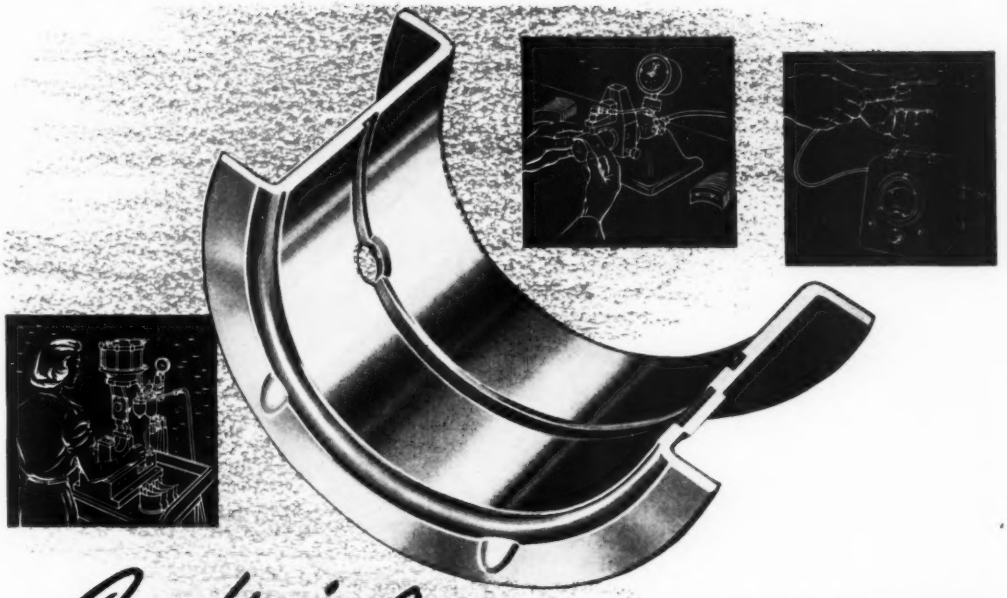


T-J CUTTERS *for more work between grinds* in tough die steels . . . accurate . . . sturdy . . . less breakage. All standard types and sizes.

Send for catalogs.
The Tomkins-Johnson Co.
Jackson, Michigan

T-J
TOMKINS-JOHNSON
RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

32 YEARS EXPERIENCE



Combining PRODUCTION IN THE MILLIONS WITH QUALITY IN THE INDIVIDUAL BEARING

To assure top quality in mass production of sleeve bearings, at low cost, our Quality Control and Production Methods organization conducts as many as 108 separate tests for material quality and physical accuracy of the individual bearing. Specialists for almost 50 years, our six-plant organization is tailored to the peculiar needs of sleeve bearing production—from original research to field tests of the finished product. Our engineering department will gladly consult with you on your problems.

28 PRECISE MACHINE OPERATIONS

84 MEASUREMENT CHECKS

24 ADDITIONAL TESTS

are conducted on a strip-type, copper-lead lined, steel-backed flanged bearing.

HIGH SPEED, high temperature, automotive type bearings available in many combinations.

SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.

HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

Power goes to work smoothly through

FEDERAL-MOGUL

FEDERAL-MOGUL CORPORATION — FEDERAL Mogul Silent SLEEVE BEARINGS — 11043 SHOEMAKER, DETROIT 13, MICH.

HOLO-KROME

Completely Cold Forged

Socket PIPE PLUGS

PRECISION MADE!

H-K Special analysis alloy steel. Sockets are true hex shape with corners clean and well defined for quick assembly. Threads perfect in lead, pitch and form and held to close limits resulting in the plugs' properly engaging the tapped hole, preventing leakage.... the reason why more pipe plug users are specifying Holo-Krome Socket Pipe Plugs. Final individual hand inspection before packaging assures guaranteed unfailing performance.

H-K Distributors are prepared to service you from their warehouse stocks.

FIBRO FORGED
SCREWS

THE HOLO-KROME SCREW CORP. HARTFORD 10, CONN.

NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep Your Library Up-to-Date

(1) SMALL MOTORS—Redmond Co., Inc., Owosso, Mich. Catalog 2a/9, 8 pages. Covers entire range of Redmond fractional hp motors, known as Micromotors, which range in size from 1/500 to 1/15 hp. Available in ventilated and totally-inclosed models.

(2) IRON SPECIFICATIONS—Gray Iron Founders' Society, 210 National City Bank Bldg., Cleveland 14, Ohio. Leaflet, 4 pages. Contains 14 sets of gray iron specifications such as those used in work with high pressure, high temperature, pipes and pipe fittings.

(3) RETAINING RINGS—Waldes Kohinoor, Truare Div., Long Island City 1, N. Y. Catalog 4K-6 (pt. 2), 28 pages. Includes chart data, such as ring dimensions, thrust load capacities, tensile strengths and types of finishes for all standard Truare rings.

(4) BEAM LOAD SELECTOR—Unistrut Products Co., 1013 W. Washington Blvd., Chicago 7, Ill. Slide Calculator. Designed to estimate the load which can be supported by various Unistrut sections under various conditions of span and unbraced height.

(5) PLASTIC MOLDING MATERIAL—Libbey-Owens-Ford Glass Co., Plaskon Div., Toledo 6, Ohio. Folder, 4 pages. Gives electrical, chemical and mechanical properties of the thermosetting plastic, Plaskon Alkyd.

(6) ENGINE-DRIVEN GENERATORS—D. W. Onan & Sons Inc., Minneapolis 5, Minn. Catalog, 19 pages. Gives information for choosing proper Onan engine-driven generating plants ranging in sizes from the portable 350 w. model to the 35,000 w diesel units.

(7) TRANSFORMERS — Allis-Chalmers Mfg. Co., S. 70th St., Milwaukee, Wis. Folder, 4 pages. Shows line of seven transformers filled with non-inflammable insulating liquid, Chlorextol, to permit installation at load centers.

(8) MOTORIZED SPEED REDUCER—Fairbanks-Morse & Co., Fairbanks Morse Bldg., Chicago 5, Ill. Leaflet, 4 pages. Contains data for selection of 15 sizes of Motorgears along with a cutaway drawing to show design.

(9) COLD-FINISHED STEEL — Jones and Laughlin Steel Corp., Cold Finished Sales Dept., Pittsburgh 30, Pa. Catalog, 14 pages. Mechanical properties, and chemical analyses, machinability and various other test data is given for the 10 different types of Jalcase steels.

(10) ELECTRICAL RELAYS—Advance Electric and Relay Co., 1260 W. 2nd St., Los Angeles 26, Calif. Catalog, 48 pages. Illustrates line of over 50 types of relays for circuit control, radio and high frequency, keying circuits, electronic applications and many other uses with a-c and d-c power sources.

(11) FUEL SELECTOR VALVES—The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio. Bulletin 521, 15 pages. Gives engineering drawings and specifications for 11 different types of valves for which there are a number of sizes. Also gives table showing series numbers of replacement valve parts.

(12) FLEXIBLE COUPLINGS—Charles Bond Co, 617-623 Arch St., Philadelphia 6, Pa., Catalog F22, 15 pages. Describes five different types of flexible couplings including data sheets on specifications.

(13) LAYTEX INSULATED CABLES—U. S. Rubber Co., 1230 Avenue of the Americas, New York 20, N. Y., Catalog, 18 pages. Includes performance characteristics and physical properties of Laytex insulated cable, and gives pictorial information on methods of wrapping with this material.

(14) WATER STILLS—F. J. Stokes Machine Co., Tabor Road, Olney P. O., Philadelphia, Pa. Catalog 41-S, 23 pages. Contains information on the operation of and applications for various laboratory and industrial models of stills having capacities from ½ to 5,000 gallons.

(15) STUD WELDER—Morton Gregory Corp., Nelson Stud Welding Division, Toledo Avenue and E. 28th St., Lorain, Ohio, Bulletin, 28 pages. Contains information on the operation and maintenance of Nelson electric arc stud welder.

(16) BEARING MAINTENANCE—Anti-Friction Bearing Mfrs. Assoc., Inc., 60 E. 42nd St., New York 17, N. Y., Bulletin, 19 pages. Reference material for the maintenance of various types of anti-friction bearings including ball, thrust, needle, tapered and straight roller bearings.

(17) SELF-COOLED FANS—ILG Electric Ventilating Co., 2850 No. Crawford Ave., Chicago 41, Ill., Catalog 148, 25 pages. Gives engineering and performance data for over 18 different fan types.

(18) NUT RETAINERS — Tinnerman Products Inc., Cleveland 13, Ohio. Bulletin 245-1, 4 pages. Gives description of and specifications for nut retainers along with tables to aid in selection.

(19) TROLLEY CONVEYORS — Smith Power Transmission Co., 1545 E. 23rd St., Cleveland 14, Ohio. Catalog 551, 4 pages. Includes specifications and description of the FlexoID overhead conveyor which permits dips and rises up to 40 percent maximum.

(20) PNEUMATIC CONTROLS—Leeds & Northrup Co., 4907 Stenton Ave., Phila-

HOW TO ORDER—Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

PLACE 3¢ STAMP HERE

PRODUCT ENGINEERING

330 West 42nd St.

New York 18, N. Y.

delphia 44, Pa. Catalog ND4B, 22 pages. Includes complete line of controllers with many illustrations and tables to show designs and performance characteristics.

(21) PIPE OUTLETS—Bonney Forge & Tool Works, Allentown, Pa. Catalog, 21 pages. Combined with temperature-pressure rating tables, catalog gives information on applications for butt welded, threaded and socket welded outlets.

(22) TORQUEMETERS — Baldwin Locomotive Works, Philadelphia 42, Pa. Bulletin 275, 4 pages. Tells how to specify torquemeter requirements and describes the working principles of meters ranging in capacity from 30 to 750,000 inch pounds.

(23) WELD PADS—The Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio. Bulletin 485, 4 pages. Gives specifications and uses for 4 different types of pads for projection welding.

(24) SPEED REDUCERS—Janette Mfg. Co., Chicago, Ill. Bulletin 10-10, 4 pages. Illustrates and gives ratings for 8 different speed reducers.

(25) COMBINATION BURNERS—Hauck Mfg. Co., 134-136 Tenth St., Brooklyn 15, N. Y. Catalog 408, 7 pages. Shows dimensional drawings and specifications for furnace burning units which can be used with either oil or gas heating in industrial applications.

(26) SILVER ALLOY BRAZING—Handy & Harman, 82 Fulton Street, New York 7, N. Y. Bulletin 17, 4 pages. Instructions for preparing, heating and brazing fittings to pipe and tubing.

(27) COLD ROLLED STEEL — Joseph T. Ryerson & Son, Inc., P. O. Box 8000-A, Chicago 80, Ill. Bulletin, 7 pages. Contains a description of finishing processes, guide to selection, AISI and SAE standard steel compositions, table of mechanical properties, and condensed listing of analyses, finishes and shapes available.

(28) REGULATING VALVES — A. W. Cash Valve Mfg. Corp., Decatur, Ill. Bulletin 265, 6 pages. Describes Type B pressure valves and contains capacity charts for water, air and steam.

(29) MAGNET CHARGER—Radio Frequency Laboratories, Inc., Boonton, N. J. Folder, 6 pages. Illustrates and describes the Model 107 magnet charger and newly developed adapters for production charging of industrial magnets.

(30) PROCESSING EQUIPMENT—F. J. Stokes Machine Co., 5900 Tabor Rd., Philadelphia 20, Pa. Catalog 49-C, 20 pages. Gives information on freeze-drying equipment, vacuum shelf dryers, Microvac high-vacuum pumps and other processing accessory units.

(31) SHAFT SEALS—Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. Leaflet, 4 pages. Gives information on and detailed drawings of the construction of two types of seals which are available in sizes from 5/16 to 5 in. inner diameter.

(32) BLIND RIVETS—Cherry Rivet Co., Los Angeles 3, Calif. Pamphlet 4k/3, 4 pages. Presents applications for and shows pictorially how both the self-plugging and pull-through types of blind rivets are installed.

(33) EXTENSOMETERS — The Baldwin Locomotive Works, Philadelphia 42, Pa. Bulletin 263, 10 pages. Offers information on construction, accuracy and methods of application of many different types of extensometers used in testing materials.

(34) STEEL ALLOYS — Haynes Stellite Co., Kokomo, Ind. Catalog, 87 pages. Good reference book which contains chapters on various Stellite alloys, Multimet and Hastelloy alloys plus methods of production of these materials. Also includes 13 graphs showing physical properties.

(35) COPPER TUBING — Superior Tube Co., Norristown, Pa. Leaflet, Pa. Leaflet, 4 pages. Presents data on physical and mechanical properties of beryllium copper tubing with OD from 1/100 to ¾ inches.

(36) STAINLESS PLATED STEEL — Alan Wood Steel Co., Conshohocken, Pa. Folder, 4 pages. Covers the applications for material made of rolled steel coated with stainless steel, and gives information for the welding of this Permaclad metal.

(37) MAGNETIC PULLEYS—Dings Magnetic Separator Co., 4740 W. McGeogh Ave., Milwaukee 14, Wis. Catalog C-1011A, 7 pages. Describes the purpose, operation principle and advantages of electromagnetic pulleys, including the design of aircooled, solid type and waterproof, greaseproof or heatproof pulleys.

(38) ELECTRICAL PARTS—Allied Electric Products, Inc., 63-65 Coit St., Irvington 11, N. J. Catalog 150, 21 pages. Gives price list and technical data on R-40 lamps, multi-purpose fluorescent starters, solderless contacts for assembly plugs, cube taps, and starter sockets.

(39) NUT-RIVET COMBINATION—The B. F. Goodrich Co., Akron, Ohio. Catalog, 27 pages. Revised edition of Rivnut Data Book telling of installation, type, sizes and grip ranges of this combination fastener along with various tables of test data.

(40) COUPLINGS AND VALVES—Roylyn, Inc., 718 W. Wilson Ave., Glendale Calif. Catalog R-100, 22 pages. Contains data on coupling-valves, caps, adapters, strainers, hose assemblies and full flow valves.

(41) PUMP AND HEATER SETS—Peabody Engineering Corp., 630 Fifth Ave., New York 19, N. Y. Bulletin 150, 4 pages. On complete line of Duplex pump and heater sets with diagramatic layouts and photographs.

(42) POWER FACTOR — Electric Machinery Mfg. Co., Minneapolis 13, Minn. Booklet 200-TEC-1077, 20 pages. Reference book explains essentials of power factor in industrial plants; and gives a digest of power factor calculation, why low power factor should be corrected, and how it can be done.

(43) BRAKE LININGS AND BLOCKS—Raybestos-Manhattan, Inc., Equipment Sales Div., 620 Fisher Bldg., Detroit 2, Mich. Bulletin 100, 12 pages. Illustrates 15 types of R/M materials, and gives specification data for 46 brake friction-linings and blocks.

(44) RECORDERS AND CONTROLLERS—Brown Instrument Co., Philadelphia 44, Pa. Catalog 15-12, 42 pages. Offers a discussion of the fundamentals of pH, oxidation-reduction potential and conductivity with examples of pH and conductivity control in chemical, electroplating, paper and steel industries.

HOW TO ORDER — Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

PLACE 3¢ STAMP HERE

PRODUCT ENGINEERING

330 West 42nd St.

New York 18, N. Y.

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

.....Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

Write in circle number of item describing one catalog wanted →

Name.....

Company.....

Address.....

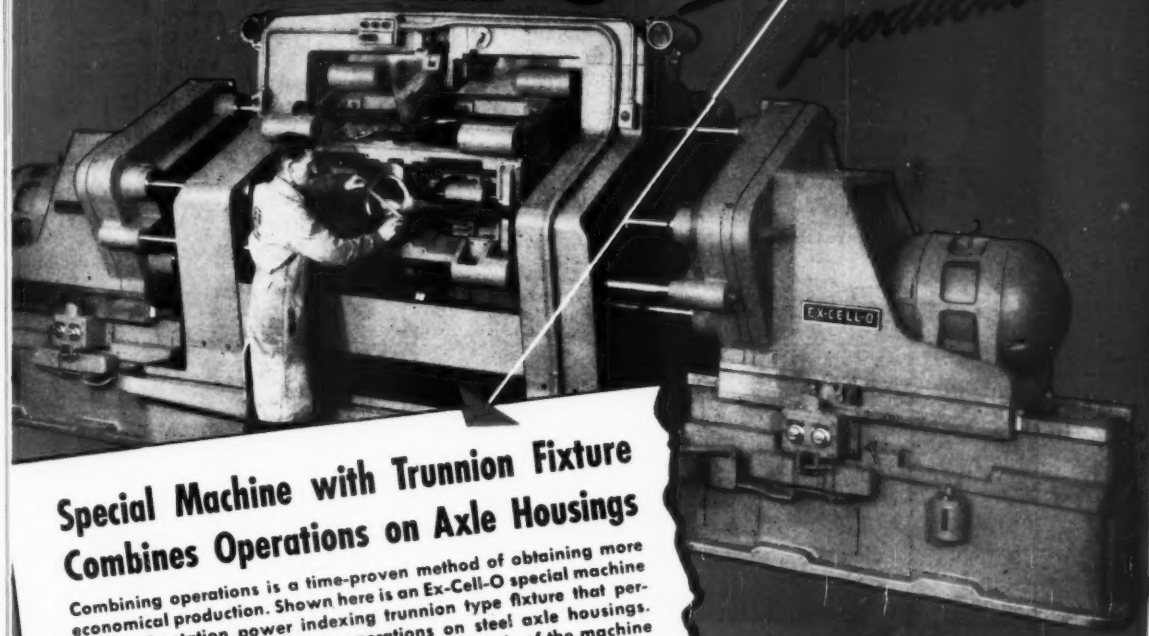
.....Title.....

PRODUCT ENGINEERING, New York. 1-49

Not good after March 1, 1949

EX-CELL-O

Can give you more economical production



Special Machine with Trunnion Fixture Combines Operations on Axle Housings

Combining operations is a time-proven method of obtaining more economical production. Shown here is an Ex-Cell-O special machine with a six-station power indexing trunnion type fixture that performs roughing and finishing operations on steel axle housings. Standard hydraulically-actuated slides at both ends of the machine carry multiple spindle heads and their drive motors. Another slide at the rear supports a precision spindle and a facing head.

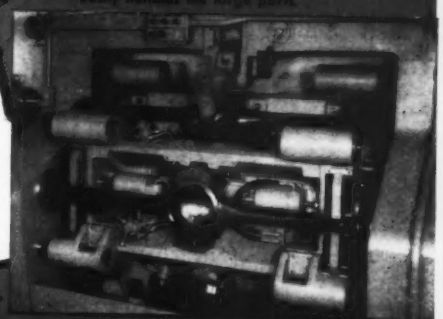
The tool holders in both the multiple spindle heads are rigidly guided by bushings in the fixture end frames. Coolant is manifolded to each station and directed through drilled holes to the point of contact between the tools and the work.

Parts are laid in the loading station and are located and clamped hydraulically. Operations are rough, semi-finish bore and ream bearing diameters at both ends; rough and finish face flanges, chamfer inside and outside edges of flanges and turn O.D. of flanges at both ends; face banjo. All these operations are performed at a net production rate of 55 pieces per hour!

Let Ex-Cell-O help you combine operations for more economical production. A complete staff of experienced machine tool engineers is ready to help you with your production problems. Contact your Ex-Cell-O representative today!

Above: Ex-Cell-O special machine performs many operations on steel rear axle housings.

Below: Close-up view of the Ex-Cell-O six-station trunnion type fixture which easily handles the large parts.



XLO

EX-CELL-O for PRECISION

EX-CELL-O CORPORATION

Detroit 32, Michigan

Special Multiple Way-Type Precision Boring Machines • Special Multiple Precision Drilling Machines • Precision Boring, Turning, and Facing Machines and Fixtures • Precision Cylinder Boring Machines • Precision Thread Grinding Machines • Precision Lapping Machines • Precision Broach Sharpening Machines • Other Special Purpose Machines • Tool Grinders • Continental Cutting Tools • Broaches and Broach Fixtures • Counterbore Sets • Grinding Spindles • Hydraulic Power Units • Drill Jig Bushings • R.R. Pins and Bushings • Fuel Injection Equipment • Dairy Equipment • Aircraft and Miscellaneous Production Parts

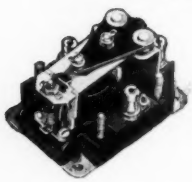
STRUTHERS-DUNN

5,348 RELAY TYPES

It pays to use relays that are SPECIFICALLY TAILORED to your application

Yours for the asking!

A HANDY GUIDE TO small RELAYS



***NEW!* A MIDGET WITH 15 AMP. CONTACTS**

Type 1HXX36: Only 1¼" x 2¾" x 2" high. Underwriters' approved. SP, DB, ST normally-open ⅜" silver contacts rated 15 amps. at 115V. AC.

This bulletin makes it easy for you to select small industrial control relays with the exact contact arrangement, mounting details and construction required for each application. In concise, easily understood form, it contains complete information on standard Struthers-Dunn Midgets and includes many available adaptations to fit these to specific operating conditions. Ask for Data Section 2100.

STRUTHERS-DUNN, INC.
150 N. 13th St., Philadelphia 7, Pa.

These District Engineering Offices To Serve You

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • INDIANAPOLIS • KANSAS CITY • LOS ANGELES MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

looking for plastics?

you'll find them easier, faster if you...

...reach for your SWEET'S

When you need specific information on materials, finishes or parts, reach for your Sweet's File for Product Designers (the big orange file). It contains 169 manufacturers' catalogs full of useful information on thousands of products . . . from absorbers—shock, to zinc. Cross indexing speeds finding.

If Sweet's File for Product Designers is not available in your office, make request immediately for application form. Files are distributed FREE to qualified organizations and individuals.

Sweet's

CATALOG SERVICE
for easier, faster selection of products
119 W. 40th ST., NEW YORK 18, N. Y.

HAND CONTROL IS OUT!

Honeywell-Brown Control Devices Have Done it for Textile Decating . . . They Can Do it for You!

TEXTILE men know the importance of keeping decating machines at top capacity. And modern mills have replaced the old "feel" method with the Honeywell-Brown control system.

Honeywell-Brown systems automatically maintain *exact* and *consistent timing* of steam and vacuum cycles. Guesswork and lost-time are eliminated . . . production is substantially increased . . . with a minimum of attention!

Honeywell-Brown control devices are setting the pace in a variety of industries! Specify them on your next job! Send for catalog 8302 . . . for detailed information!

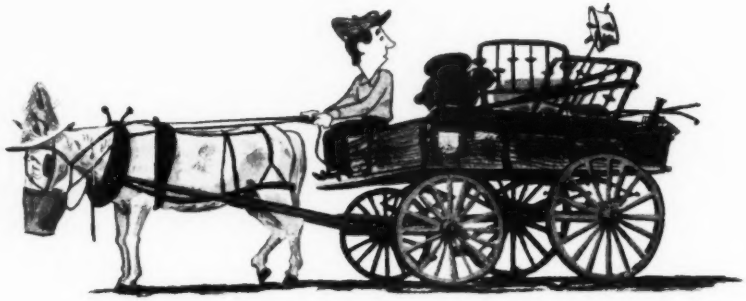
CATALOG 8302

Contains data on control devices for every machine and every process. A copy will be sent to you upon request. Write today!

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4459 Wayne Ave., Philadelphia 44, Pa.
Offices in Principal cities of the United States, Canada and throughout the world

BROWN *Advanced Instrumentation* FOR BETTER PROCESSING
Product of MINNEAPOLIS Honeywell

Nobody throws away Stainless Steel



Stainless steel *lasts*. Allegheny Metal stays bright and strong —gives lifetime service—under conditions of corrosion, heat and wear that send lesser metals to the junk-pile in a few years, or perhaps only months. Wherever a superior metal will give you advantage, you'll find it cheapest in the long run to use Allegheny Metal, the time-tested stainless steel.

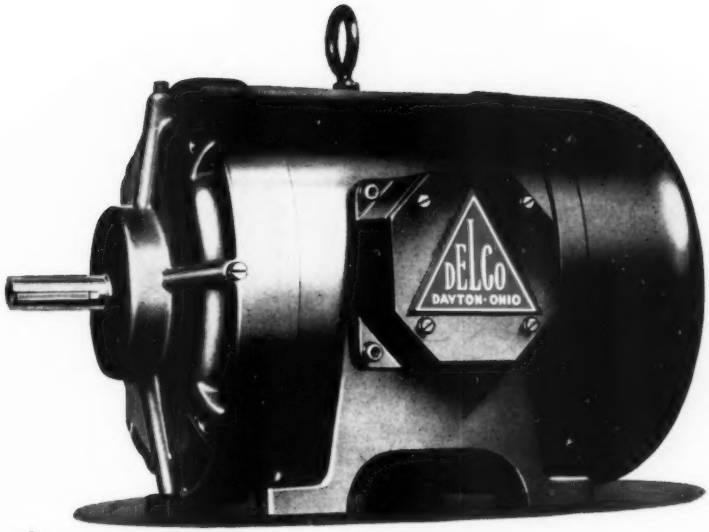
Complete technical and fabricating data—engineering help, too—yours for the asking.

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

Pittsburgh, Penna. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses



NO *down-time* WHEN

DELCO MOTORS

ARE ON THE JOB!

Down-time for repairs costs money! For motors that won't let you down . . . always deliver under the most adverse conditions . . . specify Delco motors. They combine simplicity of design with rugged construction . . . require a minimum of maintenance.

Delco's special features assure continuous, trouble-free power: Locked bearings, Delcote coil insulation, corrosive-resistant cast iron frame, positive lubrication, dynamically balanced rotor and shaft assembly, watertight conduit box—features that mean you can depend on Delco for dependable power.

Eliminate down-time with Delco motors! There is a Delco motor built to fit your needs exactly.

Delco totally enclosed fan-cooled motors are produced in sizes ranging from fractional ratings to 75 h.p. (Continuous duty, constant speed, 60 cycle, polyphase.)

For complete data on Delco Motors, address Delco Products, Dayton, Ohio, or our nearest sales office.

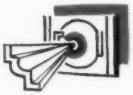
DELCO MOTORS

DELCO PRODUCTS, DIVISION OF GENERAL MOTORS CORPORATION

DELCO PRODUCTS DAYTON OHIO

SALES OFFICES: CHICAGO • CINCINNATI • CLEVELAND • DETROIT • HARTFORD, CONN.

DOGHOUSE!

A designer . . . plagued with production costs of a fluorescent reflector housing . . . solved the double problem of lightness and strength plus fast manufacture. He hadn't considered the economy of finished parts by extrusion  . . . had kept magnesium in the doghouse.

But he asked Aluminum Company of America, light metal headquarters, for help. He found that fellow manufacturers every month are using over a million pounds of magnesium. He found that magnesium machines fast, and has a high strength-weight ratio . . . . that common sense shop practice makes handling magnesium no problem.* He got technical advice and books about designing and fabricating magnesium. Now, instead of fabricating parts like this, he buys immediately available Magnesium Extrusions like this. His production time is slashed. His lighter, stronger reflector housing is outselling competition.

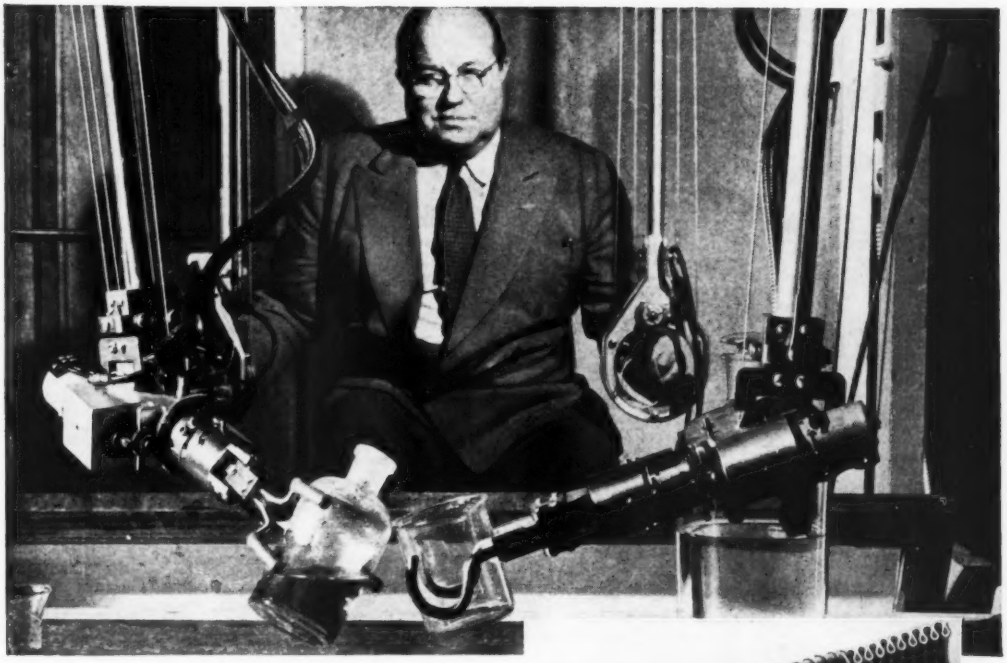
*No change in insurance rates.

These two, free books on magnesium and our broad technical experience can help your products, too. Write Aluminum Company of America, sales agent for American Magnesium products, 1702 Gulf Building, Pittsburgh 19, Pennsylvania.

MAZLO
MAGNESIUM PRODUCTS
®

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA



Inventor, John Payne, operates the amazing mechanical hands that he and other General Electric scientists, engineers and craftsmen built for the Atomic Energy Commission. It is operated through a thick wall, the manipulation being guided with the help of mirrors.

At right, cut open view of the American Seamless Flexible Metal Hose, with its protective bronze braiding, that conveys actuating brake fluid.

AMERICAN FLEXIBLE METAL HOSE

Helps Probe Atomic Secrets

THIS IS THE WAY to handle lethal, radio-active materials you dare not touch!

These robot hands, with fingers as sure and gentle as a man's, infinitely more powerful when strength is needed, are operated through a thick lead wall. Small electric motors turn the hands at the will of the operator, while other motions are mechanical, with hydraulic force applied through ¼" I.D. American Seamless Flexible Metal Tubing to operate the fingers.

In building this intricate machine the selection of indestructible and trouble-free materials was very important, since the parts themselves are liable to become contaminated and hence difficult to repair, adjust, or replace. For conveying the brake fluid that actuates the nimble steel fingers, our Type S-1, standard American Seamless Flexible Metal Tubing of bronze, was used. It is pressure-reinforced with bronze wire braid.

Whether your own problem is to convey steam, oil, water, other fluids, semi-solids or gases under varying conditions of pressure, temperature, vibration, misalignment, movement or restricted space, you may save time, money and experimentation by consulting American first. Special design to meet your own service requirements costs you nothing extra. Write for literature, and feel free to consult our Technical Department.

ANACONDA
from mine to consumer

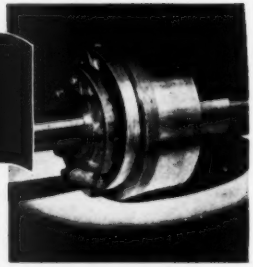
American
METAL HOSE

THE AMERICAN BRASS COMPANY
American Metal Hose Branch
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
Distributed in Canada by:
THE CANADIAN FAIRBANKS-MORSE COMPANY, LIMITED

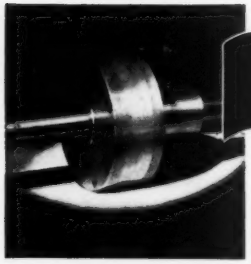
HILLIARD *Clutches*

FOR POWER CONTROL DESIGNS

HILLIARD
SINGLE
REVOLUTION
CLUTCH



Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.

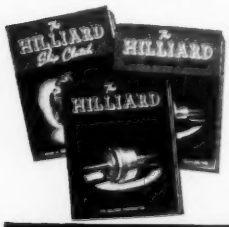


HILLIARD
OVER-RUNNING
CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drive, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD
SLIP
CLUTCH

A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.



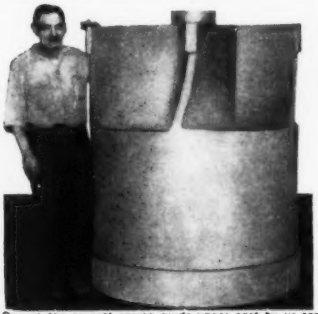
Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.

Clutch Makers for over 40 years

The HILLIARD Corporation

101 W. Fourth St., Elmira, N. Y.

A 6,500 lb. BRONZE CASTING



One of the several casing guide vanes cast by us for a well-known corporation

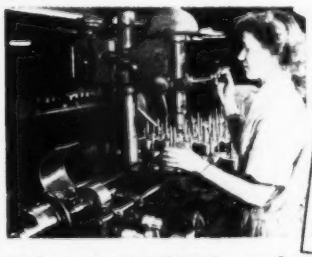
We've also made numerous similar type castings for Turbine Runners, Pump Impellers . . . and hundreds of large, accurate Ship's Propellers.

So, if you require non ferrous castings (large or small) to meet any of the following conditions, you are safe in bringing your problems to us: Corrosion Resistance; Strength in Tension and Compression; Hardness and Toughness; Pressure Tightness; Erosion Resistance; Frictional Wear Resistance or Fatigue Resistance. Would you like a copy of our 46-page flexible-bound Reference Book entitled, "BRONZE CASTING ALLOYS"? If so, write us on your business letterhead.

AMERICAN MANGANESE BRONZE COMPANY

4705 RHAWN ST. HOLMESBURG, PHILADELPHIA 36, Pa.
Pittsburgh, Pa.
40 YEARS' EXPERIENCE

CASE REPORT No. 51 from a series of actual cases recording the successful application of BEAR DY-NAMIC BALANCING to Industry.



Pezzillo Pump Co. Philadelphia, Pa. —reports greater quietness, smoothness of operation and better performance since balancing their rotors on Bear Machines. Approximately a minute and a half required for each rotor. They say Bear Balancing Machines are easy to operate trouble free, fast in production!

250 to 300 ROTORS per day
DY-NAMICALLY BALANCED
—on Bear Balancing Machines at Pezzillo Pump Company.

Benefits of Dy-Namic Balancing which they report, can be yours, too, when you use Bear Machines to balance rotating parts. Select the machine that fits your need, from the new Bear Dy-Namic Balancing Manual.

FREE MANUAL Tells How to Balance All Rotating Parts

This new Dy-Namic Balancing Manual tells you how you can easily, quickly, economically balance rotors, armatures, crankshafts, and other rotating parts, weighing from 4 oz. to 8 tons. Also tells how Bear Dy-Namic Balancing Reduces Wear on Rotating Parts, Eliminates Noise and Vibration, Improves Efficiency of Finished Product. SEND FOR YOUR COPY, TODAY. Address **Bear Mfg. Co., Dept. P-5, Rock Island, Ill.**

BEAR STATIC AND DY-NAMIC BALANCING MACHINES

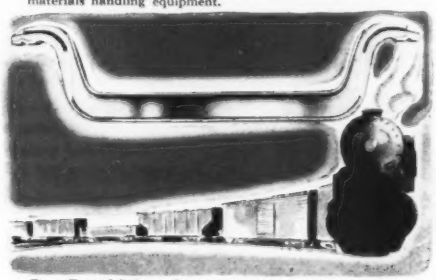
When You Use a *FORGING*, You Have Done All That Can Be Done to Forestall Unpredictable Parts Failures

Macro-etch through longitudinal cross-section of pinion rack used on power shovel shows fiber-like structure in rack teeth which provides maximum resistance to wear, and strength and toughness for shocks and stresses occurring continually when in use. This fiber-like structure is common in all high quality forgings.

THERE IS NO SUBSTITUTE for the strength and toughness inherent in the forged fiber-like flow-line structure of forgings. The forging method of fabricating parts in closed impression dies directs, controls and concentrates the fiber-like flow-line structure of metals at points of greatest shock and stress. In forgings you obtain the strength and toughness for unrelenting and uninterrupted performance. When you use a forging, you have done all that can be done to forestall the failure of parts and to protect the user of your equipment from unpredictable emergencies. Forgings provide rapid assembly of complex parts as by welding; forgings permit reduction of dead weight because maximum strength and toughness are obtainable in lighter sectional thicknesses. The metal quality and cost-reducing advantages obtainable in forgings cannot be equalled or duplicated. Recheck every stressed part in your equipment, and consult a forging engineer about possibilities for reducing costs of machining and finishing, speeding up assembly and improving performance. Only a forging engineer can inform you fully regarding the many advantages of forgings.

DROP FORGING ASSOCIATION
605 HANNA BUILDING • CLEVELAND 15, OHIO

The steering mechanism of Towmotor lift trucks must operate smoothly at all times and under all kinds of loading without failure. To insure such trouble-free performance, the engineer designed this steering knuckle to be a forging, thereby obtaining a greater factor of safety which is so essential in materials handling equipment.



Drop Forged I-Beam Equalizer weighing 405 lbs. replaces an 800 lb. unit on freight cars. This illustrates how forgings reduce dead weight, yet provide a greater factor of safety that is so important in railroad operation. This drop forged I-Beam requires less machining and processing, and scrap loss is almost totally reduced because forgings are unusually free of concealed defects.

DROP FORGING ASSOCIATION

DROP FORGING ASSOCIATION
605 HANNA BUILDING • CLEVELAND 15, OHIO

☐ Booklet on "Metal Quality — Hot Working Improves Properties of Metal."

☐ "Drop Forging Topics" which presents numerous end use applications of forgings.

Name ..... *Position* .....

Company .....

Address ..... *City* ..... *State* .....

LARGE OR SMALL... SAME TOP QUALITY IN ALL!

When it comes to quality, Aetna has a one-track mind—a mind inflexibly focused on bringing into being the finest anti-friction products it is possible to produce for the intended application.

When you use Aetna bearings—one or a million, for ordinary or highly specialized applications—you can count on performance that's backed by the safety factor of plus quality.

For all new applications, for all replacements, rely on Aetna quality and engineering service for lowest bearing cost in the long run.

Write for new 52 page engineering catalog. No cost. No obligation.

AETNA BALL AND ROLLER BEARING COMPANY
4600 SCHUBERT AVENUE • CHICAGO 39, ILLINOIS

Aetna
BALL AND ROLLER BEARINGS

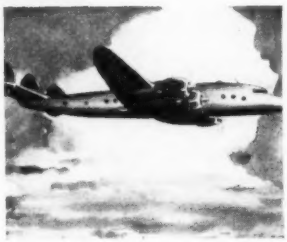
STANDARD AND SPECIAL BALL THRUST BEARINGS • SPECIAL ROLLER BEARINGS • ANGULAR CONTACT BALL BEARINGS • BALL RETAINERS • HARDENED AND GROUND WASHERS • SLEEVES • BUSHINGS

Seven new planes completed at a cost of $4.30!

New planes can't fly without control cable, and this manufacturer needed some—fast. He got it the same way he regularly gets many supplies and parts—by Air Express. Ordered in A.M., delivered to plant same day, 500 miles, 28 lbs., Air Express charge only $4.30. So production continued without a break.

$4.30 included pick-up and delivery at no extra charge—and receipt for shipment. All this, plus the *world's fastest shipping service.* That's Air Express—used with profit by every business.

Shipments go on all flights of Scheduled Airlines. Speeds up to 5 miles a minute—no waiting around. Direct service to over 1,000 airport cities, air-rail for 22,000 off-airline offices.



Facts on low Air Express rates:

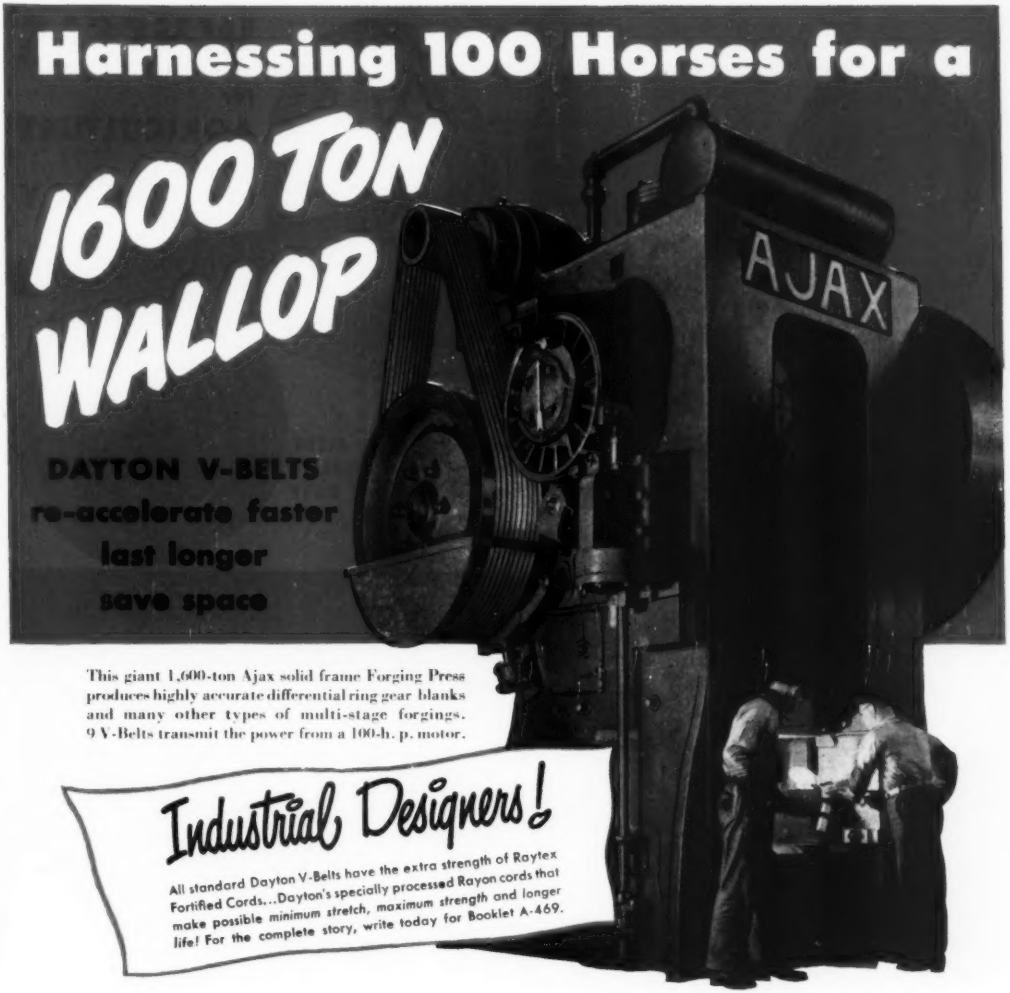
22 lbs. of new fashions goes 700 miles for $4.73.
6-lb. carton of new jewelry line goes 1,000 miles for $2.24.
Same day delivery in both cases if you *ship early.*

Only Air Express gives you all these advantages: Special pick-up and delivery *at no extra cost. You get a receipt for every shipment* and delivery is proved by signature of consignee. One-carrier responsibility. Assured protection, too—valuation coverage up to $50 without extra charge. Practically no limitation on size or weight. For fast shipping action, phone Air Express Division, Railway Express Agency. And specify "Air Express delivery" on orders.

SPECIFY AIR EXPRESS
GETS THERE FIRST

AIR EXPRESS, A SERVICE OF RAILWAY EXPRESS AGENCY AND THE
SCHEDULED AIRLINES OF THE U.S.

Harnessing 100 Horses for a 1600 TON WALLOP



DAYTON V-BELTS
re-accelerate faster
last longer
save space

This giant 1,600-ton Ajax solid frame Forging Press produces highly accurate differential ring gear blanks and many other types of multi-stage forgings. 9 V-Belts transmit the power from a 100-h. p. motor.

Industrial Designers!

All standard Dayton V-Belts have the extra strength of Raytex Fortified Cords...Dayton's specially processed Rayon cords that make possible *minimum stretch, maximum strength and longer life!* For the complete story, write today for Booklet A-469.

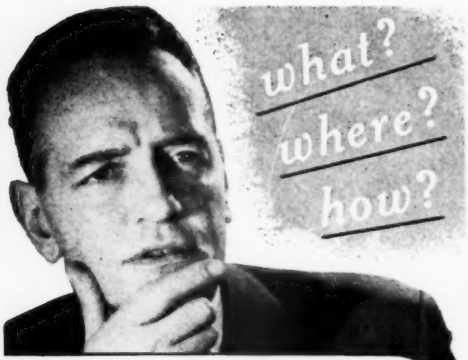
Transmitting the power from a 100-h. p. motor to the flywheel of this forging press is a perfect example of the superiority of Dayton V-Belt Drives. Here, maximum drive efficiency, rapid re-acceleration after flywheel slowdown, continuous operation and compactness of the drive are advantages the designer desires.

And he gains them all with Dayton V-Belt Drives. First, Dayton V-Belts are the most efficient method of transmitting power known. They withstand the stresses and strain of sudden starts, stops and shock loads. They transmit full power, fast. They flex around the pulley easily, without heating. And they save space by permitting the use of shorter centers, smaller pulleys.

Made with super-strength Raytex Fortified Cords, Dayton V-Belts offer minimum stretch, maximum strength, longer life. They are unaffected by oil, heat or abrasive conditions. No matter what your power transmission problem, there is a Dayton V-Belt Drive that will solve it perfectly. Dayton Power Transmission Specialists stand ready to help you at any time. Write or phone *The Dayton Rubber Company, Dayton 1, Ohio, today.*

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER



maybe this Folder will give you the answer

• If the problem has to do with transmitting reciprocal action from one place to another, TRU-LAY Push-Pull very likely is the best answer. Read these highlight facts about TRU-LAY Push-Pull.

It . . .

. . . is as positive in action as a steel rod, yet flexible as wire rope

. . . will operate over long or short lengths, with few or numerous bends

. . . will operate while flexing

. . . is made in capacities up to 1000 pounds input

. . . is precision-made, assuring minimum backlash and long life

If you do not have a copy of this descriptive folder, write to our Detroit office

ACCO

6-235 General Motors Bldg., Detroit 2
1119 Santa Fe Avenue, Los Angeles 21 • Bridgeport, Conn.

AUTOMOTIVE AND AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

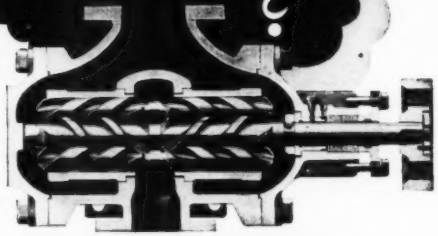
In Business for Your Safety

WHEELS
for
AGRICULTURE
and
INDUSTRY

SIZES, TYPES and QUALITY for EVERY DUTY

FRENCH & HECHT
DIVISION
KELSEY-HAYES WHEEL COMPANY
DAVENPORT, IOWA
Wheel Builders Since 1888

PUMP NOISE A NUISANCE?



Install an **IMO**

The IMO Pump has no valves, reciprocating parts, or gears to cause noise and vibration. The rotors of the IMO oil pump turn smoothly and quietly.

IMO pumps can be furnished for practically any capacity and pressure required for oil, hydraulic-control fluids and other liquids.

Send for Bulletin I-144C.

IMO
I MOVE OIL

IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

A Revealing New Book —**Here's the inside story on how manufacturers of a wide range of products have found that it pays to use magnesium. It's a book of actual case studies of successful magnesium applications—a book that will be of direct interest to you.**

How Magnesium Pays!

IN HOUSEHOLD GOODS

PROBLEM:

Easy portability is an important sales factor in this product. That's why the manufacturer considered changing basic materials. Furthermore, he wished to produce a portable full-size machine. The material selected had to be light, yet possess good machining characteristics and be receptive to a decorative finish.

SOLUTION: Through the use of magnesium, the total weight of the machine is reduced from 31 to approximately 19 pounds—a saving of 12 pounds. A magnesium sand casting weighing approximately 3 pounds is used for the sewing arm. The bed plate is a magnesium casting weighing 1½ pounds. The easy machinability of magnesium greatly simplifies the fabrication of these parts. A baked-on, nonglare finish is easily applied to the magnesium parts to provide an attractive finish.

YOU, TOO, CAN MAKE MAGNESIUM PAY!

Magnesium pays for others—it can pay for you. Get the facts—send for this new study today.

Send me the study MP 49-13 "How Magnesium Pays" without obligation.

Name_____

Title_____

Firm_____

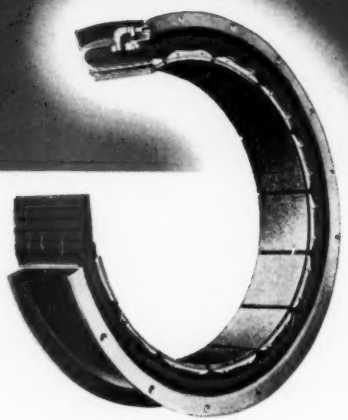
Address_____

MAGNESIUM DIVISION • THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

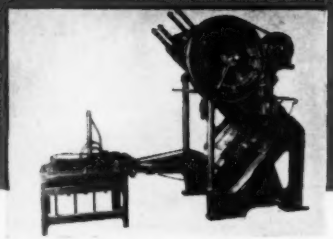
New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis
Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

ONLY ONE MOVING PART

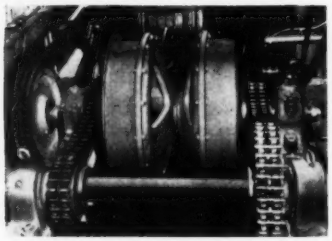
in this Fawick Clutch



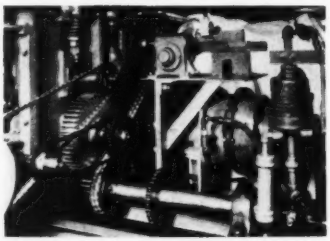
Fawick Airflex Clutch Type CB



Fawick Airflex element assembly, with 4 Fawick Quick Release Valves, on Callahan Can Machine Co. die crown cap blanking press.



Special Veneer Lathe equipped with 2 Fawick Airflex Speed Changing Clutches.



2 Fawick Airflex elements used as clutch and brake on "One Revolution Knife" by Roofing Machinery Manufacturing Co.

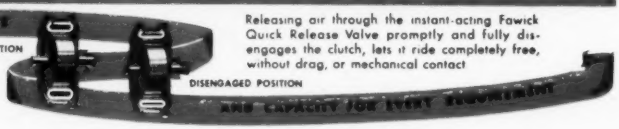
The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

Job-tested, Fawick Clutches meet the toughest operating conditions in many fields—petroleum, earth-moving, metalworking, rubber, paper, pulp and others.

Write our engineering department for a recommendation of the Fawick elements best suited for your machines. Address Dept. PE.

FAWICK Airflex CO., INC.
9919 CLINTON ROAD CLEVELAND 11, OHIO

THERE IS A FAWICK CLUTCH OF PROPER TYPE AND CAPACITY FOR EVERY REQUIREMENT



ENGAGED POSITION

Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact

DISENGAGED POSITION

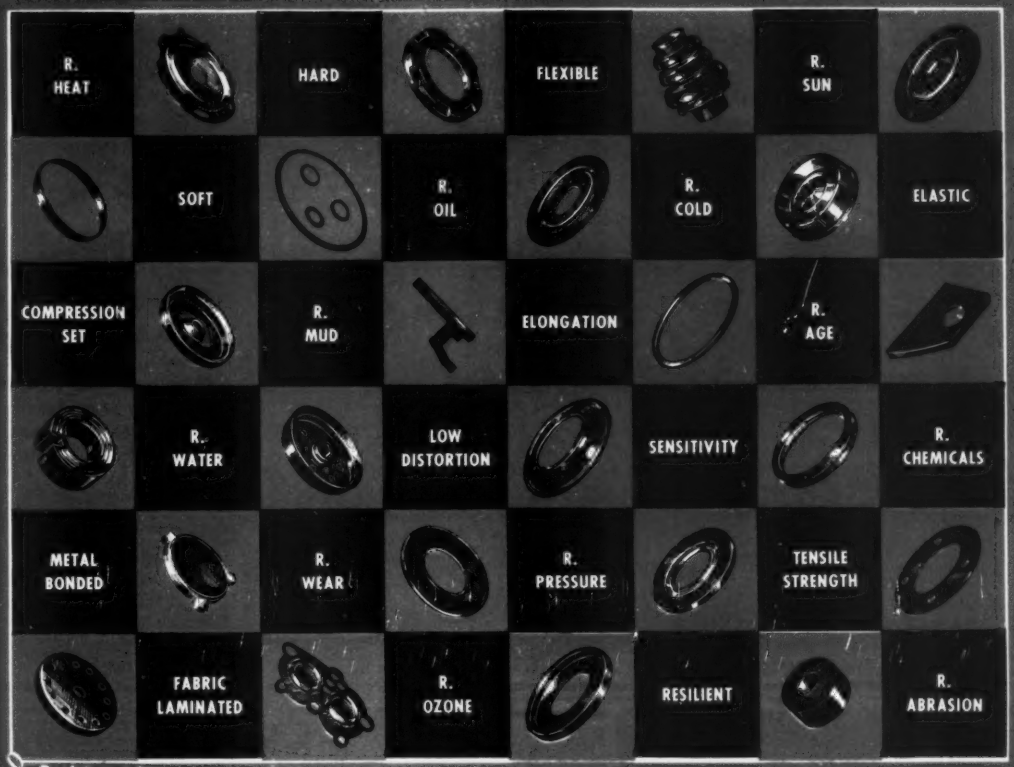


CHART FOR THE IMPOSSIBLE

To figure out all the conceivable ways that physical characteristics, design variations and resistance properties can be combined in Sirvene parts would be nearly impossible. And a great waste of your time, because only *one* combination will do the job for you. Sometimes even that combination seems impossible—and that's when you need the help of Sirvene engineers. Taking your specific performance requirements, they'll assist you in perfecting the design, then work out the proper combination of oil-resistant elastomers, do the developmental work and produce the parts in quantity under strict laboratory control. You can depend on uniform quality and micrometric accuracy in every part. When you are in a tough spot for the right flexible part to do a critical mechanical protection or sealing job—and to keep on doing it under rough service conditions—call on Sirvene.

OTHER C/R PRODUCTS
PERFECT Oil Seals
SIRVIS Mechanical Leather

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables.

CHICAGO RAWHIDE MANUFACTURING CO.
1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

New York • Philadelphia • Detroit • Los Angeles • Cleveland • Boston • Pittsburgh • San Francisco • Cincinnati
Portland • Syracuse • Peoria

SIRVENE

THE *SCIENTIFIC* COMPOUNDED ELASTOMER

Product Improvement gets a lift . . . . . .

SPRINGS

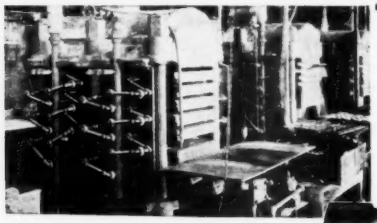
WIRE FORMS

SMALL STAMPINGS

when B-G-R applies modern springmaking methods to your specifications. For samples, experiment or prompt production, call a B-G-R representative for helpful suggestions.

Springs by BGR

BARNES-GIBSON-RAYMOND
DIVISION OF ASSOCIATED SPRING CORPORATION
Two Plants for Spring Service . Detroit 11, Michigan Ann Arbor, Michigan



STYLE B

FOR EXACT PIPE ALIGNMENT WITH FREE MOVEMENT . . . USE

FLEXOJOINTS

Wherever high or low pressures must be conveyed to moving pipe lines, you can count on Flexo Joints for dependable, long-life service. Provided in four styles for standard pipe sizes from ¼" to 3", sturdy Flexo Joints meet all mechanical requirements—plus these extra features:

- Complete 360° swivel, with unrestricted flow in all positions.
- Eliminates steam condensate pockets.
- Maintains even flow of pressure and corresponding temperature.

Simple construction assures less maintenance. No small parts, no springs, no ground surfaces to wear. Fully enclosed from grit and dirt.

Write for details and specifications

FLEXO SUPPLY COMPANY, INC.
4650 Page Blvd. St. Louis 13, Mo.
In Canada: S. A. Armstrong, Ltd., 115 Dupont St., Toronto 5, Ont.

RIGHT WHERE IT COUNTS

Diefendorf Gears are "right on the job"—cut to specifications of all wanted materials. Design and engineering aid where required. Experimental and production facilities.

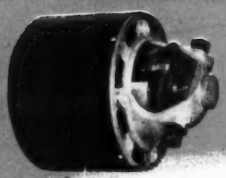
DIEFENDORF GEAR CORPORATION
Syracuse 1, N. Y.

DIEFENDORF GEARS

Dependable Motors for Dependable Products...

Lamb Electric MOTORS

Rugged construction is a major factor in the reliability of this motor widely used in the field of mechanized equipment.



Composite designed turbine . . . driven by a high-speed series motor . . . particularly adaptable to the cannister type vacuum cleaner.

This fan motor has rubber grommeted supporting lugs to assure quiet, vibrationless operation.

Space factor in this power unit is minimized by having output shaft at right angles to motor shaft.

Universal motor used for commercial vacuum cleaners, wheel balancers, air compressors, etc.

Long, trouble-free operation—a characteristic of Lamb Electric Motors—results from the quality of engineering, manufacturing, inspection and testing developed in our 34 years' experience in the small motor field.

This high standard of *motor* dependability is an important factor in obtaining good product performance . . . another reason why Lamb Electric Motors are being teamed up with more and more of America's *finest* products.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

Lamb Electric SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

CUSTOMERS ARE SATISFIED BUT WE'RE NOT....

THE BUTTON MACHINERY CO.
MANUFACTURERS OF
IVORY BUTTONS

HOBOKEN, N. J.

October 22nd, 1948.

Curtis Universal Joint Co. Inc.,
4 Birnie Avenue,
Springfield, Mass.

Gentlemen:-

We have your letter of October 21st in regard to advertisements you expect to run in the trade publications.

We are using four 1/8" C-541 standard Curtis universal joints. The first application being in April of this year on a drill for a four hole turntable Ivory Button. This drill operates on a semi-automatic turning and drilling. This drill operates continuously since April with no trouble whatsoever and no apparent wear at this time.

The drills operate at 5,000 R.P.M. and drilled in excess of 1,500,000 buttons at this time. We might add that these joints have given us more satisfaction than any we have had before.

We will forward to you within the next few days glossy prints showing the joint incorporated in our machine.

Yours truly,
THE BUTTON MACHINERY CO.

Oct 11th 1948
R.E. Curtis
Mr Fraissard on phone today advises these joints still operating O.K.
T.B.C.

We're never satisfied—we're constantly improving Curtis Universal Joints. Curtis "Standards" today are far higher than in 1946 or the preceding war years.

Static torque breaking load is greater on many sizes — New "LO-FRICTION" Center Blocks reduce frictional heat and increase overload capacities — closer production tolerances with selective assembling — all are improvements that combine to make Curtis Standard Universal Joints the strongest, most durable, and over a period of time — the most economical industrial joint that can be specified.

Write Dept. B-2

CURTIS UNIVERSAL JOINT CO. INC. SPRINGFIELD MASS.

HEVI DUTY ELECTRIC COMPANY

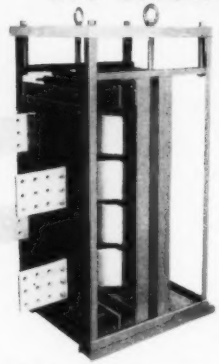
HEVI DUTY

TRANSFORMERS

are ENGINEERED for

Special

APPLICATIONS



Here is a Hevi Duty Transformer with bus bar secondary for supplying low voltage and high current to apparatus such as salt bath furnaces or carbon heating elements . . . a typical example of Hevi Duty engineering of transformers for special applications.

Send us your special transformer problems. Our engineers will gladly assist in solving them.

HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

From pole to pole and around the equator — you meet users of ESCO products. For nearly 50 years ESCO has made it a specialty to answer your needs for specially designed rotating electrical equipment. ESCO units — built-to-order generators, converters, dynamotors, special DC, AC, and universal motors — are dynamically balanced and individually tested under load conditions. Do not hesitate to send us your problem. ESCO will provide applicable data without obligation.

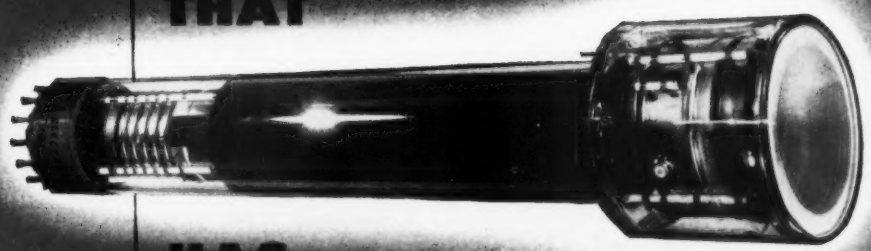
Made to order

ELECTRIC MOTORS • GENERATING PLANTS • GENERATORS
MOTOR GENERATING SETS • DYNAMOTORS • CONVERTERS

Electric Specialty Co.
170 SOUTH STREET, STAMFORD, CONN.
ESCO

THE TUBE THAT HAS DONE MOST FOR TELEVISION HAS 95% NICHROME* V METAL PARTS

The 5655 has three sections: (1) Image, (2) Scanning, (3) Multiplier. The image section contains a semi-transparent photocathode on the inside of the face plate, and on this the scene televised is focused by an optical lens system. This causes the photocathode to emit a stream of electrons from each illuminated area (proportional to the light striking the area), and these are focused on one side of the "target" where they produce a charge pattern. The opposite side of the target is scanned by a low-velocity electron beam from an electron gun in the scanning section. Electrons from the beam are turned back at the target forming a return beam which has been amplitude modulated by deposition of the electrons at the target, in accord with the charge pattern whose more positive areas correspond to highlights of the televised scene. In the multiplier section, the return beam is directed to a 5-stage amplifier (using secondary emission to amplify electron beam signals), and here the modulated beam is amplified at least 100 times—to drive the first stage of the video amplifier.



This is the RCA Image Orthicon 5655—super-sensitive eye of the television camera. Developed primarily for studio use and applications employing artificial illumination, it is several times more sensitive to light at low levels than the fastest motion picture film.

Only 15¼" long, it has over 150 precision-made parts, many assembled under microscopes.

These parts must remain unmagnetized by the strong magnetic fields of the focusing and deflection coils that surround the tube. Magnetized, they would produce fields of their own, and prevent proper operation.

When the parts are assembled, the glass housing of the tube is sealed. Temperature of the glass during sealing operations is raised to over 1600°F., temperature of the parts to as much as 900° F.

Under these conditions of manufacture, the alloy used must not only be entirely non-magnetic but possess high resistance to heat and oxidation. The only alloy that most satisfactorily meets these specifications is Nichrome V. *That is why 95% of the metal parts in the RCA Image Orthicon 5655 are made of Nichrome V.*

Driver-Harris manufactures over 85 alloys for the Electronic and Electrical fields. These are distinguished for giving exceptionally efficient, long and economical service—most particularly where requirements are unusually tough. So send us your specifications. As with the Image Orthicon, it is most probable a D-H alloy will best solve your manufacturing problems.

*Nichrome is manufactured only by

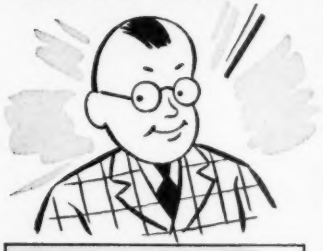
Driver-Harris Company

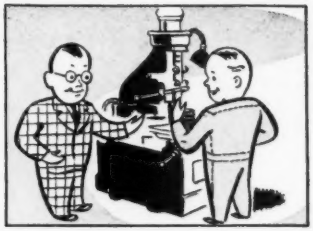
HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle
Manufactured and sold in Canada by
The B. GREENING WIRE COMPANY, LTD., Hamilton, Ontario, Canada

*T.M. Reg. U. S. Pat. Off.

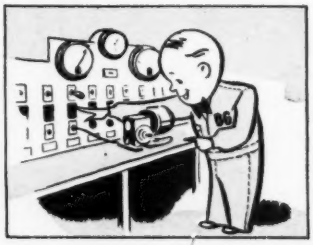
"It's QUALITY CONTROL that sold me on Boston Gears!"





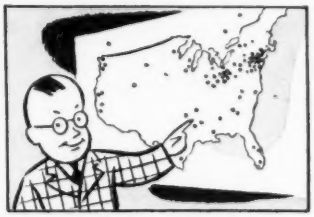
"67 years of experience give Boston Gear Works a big edge in know-how and craftsmanship. They've worked out processes and techniques that build *extra* quality into their products."

"Everything is checked and tested. Boston Gear controls its own materials and alloys . . . uses only virgin metals . . . tests its materials for hardness and tensile strength . . . tests its products for shock strength, hardness and wear."



"Every craftsman is an Inspector . . . makes sure previous operation is properly done before he starts . . . inspects his entire run and he's double checked by our elaborate Central Testing Lab."

"Engineers can design around Boston Gear stock parts with complete assurance of success . . . manufacturers can cut costs *safely* with these mass production masterpieces. Rigid inspection of all production for exacting tolerances and size of finished products is your guarantee of perfect interchangeability."

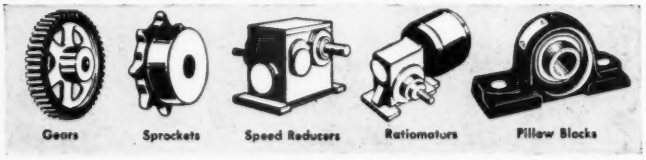


"And Boston Gear products are sold coast to coast through 71 DISTRIBUTORS. There's one within fast shipping time of *your* plant . . . and you can now buy most Boston Gear products *right off the shelf!* See our THOMAS' REGISTER insert under Gears & Pinions for your nearest source . . . or write for list of Authorized Distributors.

One of the world's most complete lines . . . 71 Distributors in major cities

BOSTON GEAR WORKS

82 Hayward St., Quincy 71, Mass.



need fasteners?

you'll find them easier, faster if you...

...reach for your SWEET'S

When you need specific information on materials, finishes or parts, reach for your Sweet's File for Product Designers (the big orange file). It contains 169 manufacturers' catalogs full of useful information on thousands of products . . . from absorbers—shock, to zinc. Cross indexing speeds finding.

If Sweet's File for Product Designers is not available in your office, make request immediately for application form. Files are distributed FREE to qualified organizations and individuals.

Sweet's

CATALOG SERVICE

for easier, faster selection of products

119 W. 40th ST., NEW YORK 18, N. Y.

"STUCK" FOR METAL?

Fabricated Masonite Presdwood*

Don't be disturbed over your lean metal supply—you're not stuck for *material!*

Take a tip from hundreds of manufacturers and switch to Masonite, the versatile hardboard, for many of your shapes, parts and sub-assemblies.

Woodall fabricated Presdwood is now being used to advantage throughout industry—in automobiles, radios, trains, boats, refrigerators, stoves, washing machines and a host of other products. We design, fabricate and supply Presdwood parts that prove less expensive, more practical for a great number of widely varied applications.

What is your problem? Call or write us today. WOODALL INDUSTRIES, INC., 7563 McNichols Road, Detroit 5, Michigan.

* In addition to Presdwood, Woodall fabricates other sheet materials as determined by the application. Twenty-nine years of research and engineering experience underwrite Woodall's fabricating ability.

Nationwide Fabricators **WOODALL INDUSTRIES INC.** *for Industrial Assembly*

Plants in: LONG ISLAND CITY, N. Y. • CLEVELAND • DETROIT • MONROE, MICH. • CHICAGO • LAUREL, MISS.

Now Ready

DIALCO

The

NEW HANDBOOK

. . . 192 PAGES of
USEFUL INFORMATION

Engineers, designers, purchasing agents —

GET YOUR COPY

You will find complete data on the lamps used in pilot lights.

And illustrations — all full size — of hundreds of items you will use.

There is a table of resistors for operation of lamps on all voltages.

Complete dimensional data on each unit.

More than 2,000 Underwriters' Listed Pilot Light Assemblies.

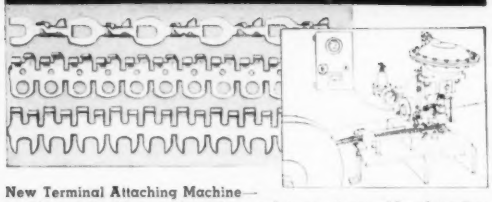
The DIAL LIGHT COMPANY of AMERICA

Foremost Manufacturer of Pilot Lights

900 BROADWAY, NEW YORK 3, N. Y.
TELEPHONE SPRING 7-1300

Write for Handbook G-149

Now Terminals Can Be
ATTACHED & SOLDERED
in ONE Automatic Operation!



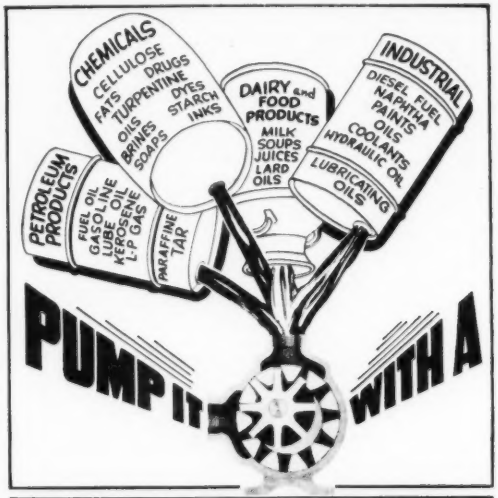
New Terminal Attaching Machine—attaches and solders various sizes and types of pre-soldered tandem terminals (supplied on reels) at rates up to 1200 per hour. Machine cuts off, clinches and solders terminals in one instantaneous operation. Eliminates handling of loose terminals, solder and flux to increase production and lower costs on long runs. Standard types available. Strong, perfectly soldered joints are assured, as absolute control of heat is maintained. Send for detailed information, enclose sample of wire and terminal now used. Address Dept. B.

For ordinary runs in moderate quantity we continue to produce

SEPARATE TERMINALS for ELECTRIC WIRES

We also make SMALL METAL STAMPINGS, exact to Customer's Prints. Modern Plant, Equipment and Methods. Precision Work. Moderate Die Charges. Prompt, Dependable Service.

PATTON-MacGUYER COMPANY
17 Virginia Avenue, Providence, R.I.



VIKING

If your problem is to pump any of these or similar liquids, look to Viking for your answer. Capacities ½ to 1050 gpm—pressures to 200 psi.—500 psi on hydraulic oils.

Send for free bulletin 47SX today.

See Our Catalog In SWEETS

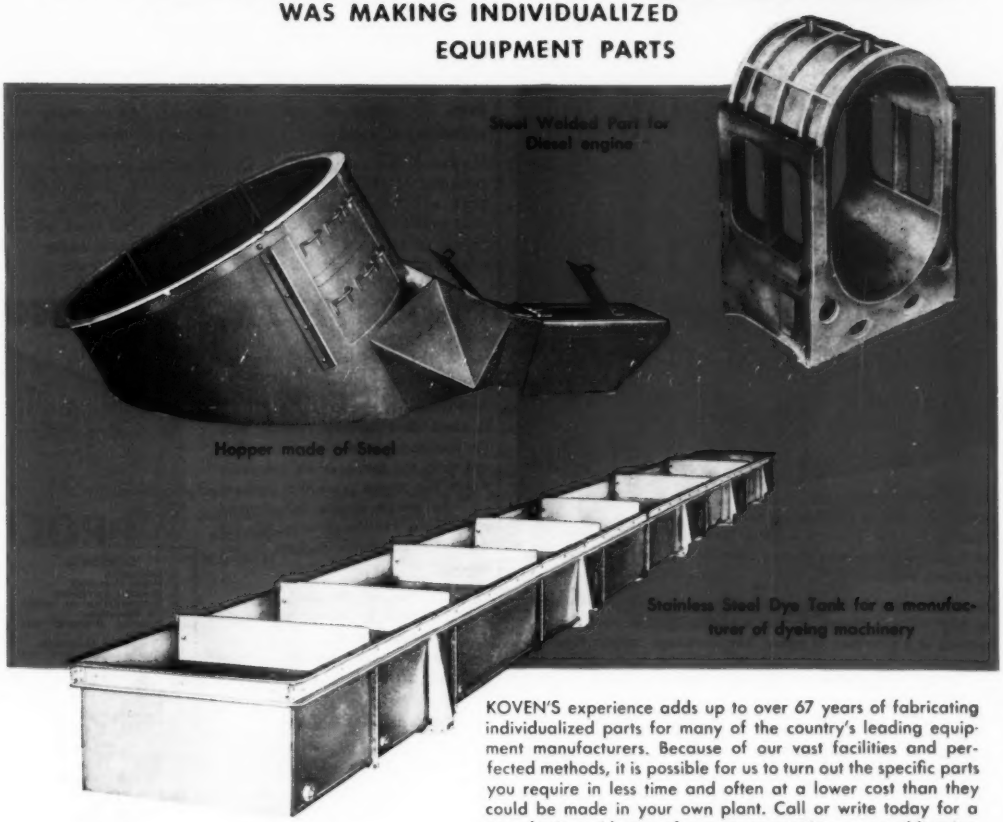
Viking PUMP COMPANY
Cedar Falls, Iowa

BACK IN THE 1880's

WHEN THE METROPOLITAN OPERA HOUSE OF NEW YORK WAS OPENED

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS


Steel Welded Part for Diesel engine
Hopper made of Steel
Stainless Steel Dye Tank for a manufacturer of dyeing machinery

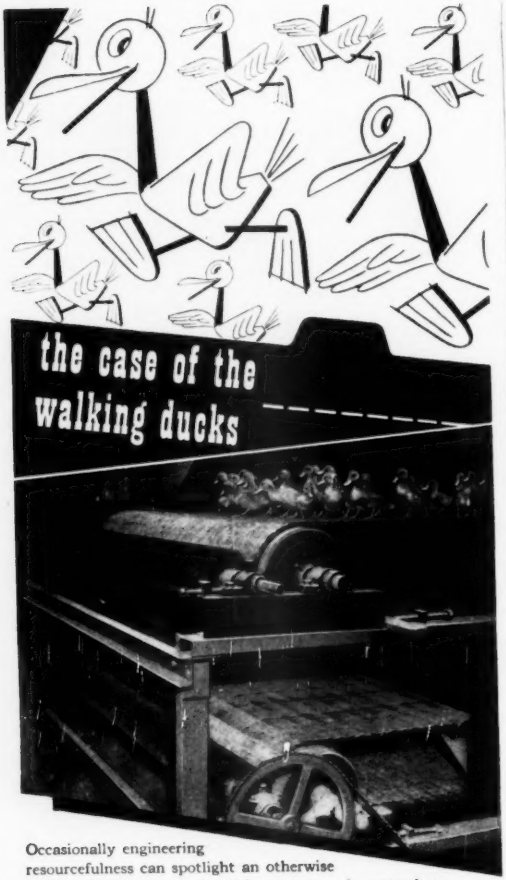
KOVEN'S experience adds up to over 67 years of fabricating individualized parts for many of the country's leading equipment manufacturers. Because of our vast facilities and perfected methods, it is possible for us to turn out the specific parts you require in less time and often at a lower cost than they could be made in your own plant. Call or write today for a consultation with one of our representatives . . . no obligation.

PLANTS:
Jersey City, N.J. Dover, N.J.

Our two modern plants are equipped with machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray inspection insures quality control.

L. O. KOVEN & BRO., INC.
154 Ogden Ave., Jersey City 7, N. J.

KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881



Occasionally engineering resourcefulness can spotlight an otherwise plain industrial product with a new and unusual use . . . such as the case of this Woven Wire Conveyor Belt installation in a duck brooder.

Newly hatched ducklings, it seems, have to be kept moving to be kept alive. Placed on this specially built woven wire belt moving at a slow rate of speed, the ducklings remain there for eight days . . . continually treadmilling away from the falling end of the belt. Mortality rate dropped to zero. By-product recovery . . . duck droppings for fertilizer . . . is aided by the open mesh of the woven wire belt.

Even if you don't operate a duck hatchery, call in a Cambridge engineer whenever you have a problem concerning the movement of materials or products during processing. Let him explain the superior construction features of . . .

CAMBRIDGE Woven Wire Conveyor Belts

This illustrated 130 page catalog—FREE—to men concerned with production control. WRITE TODAY.

Cambridge Wire Cloth Co.

Department P • Cambridge 1, Maryland

NEW YORK • BALTIMORE • PITTSBURGH • SAN FRANCISCO
BOSTON • DETROIT • CHICAGO • ST. LOUIS • HOUSTON

Manufacturing know-how that shows you

How to make accurate cost estimates directly from the blueprint

Here's a money-saving book that gives you scientific methods for determining—*directly from the blueprint*—the material and production costs of any article manufactured in a machine-shop. It tells you how to go about estimating the exact expenditures involved in labor, machine time, materials, overhead . . . and shows you how to set up efficient production methods.

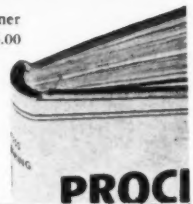
Every technique is explained step-by-step — every explanation is made clear with on-the-job demonstrations

No matter what combination of forming and machining processes a particular job calls for—drilling, milling, grinding, reaming, assembling, etc—this book provides concrete methods for arriving at the exact cost of the entire job . . . a scientifically accurate figure you can depend on to reflect a true picture of the actual cash outlay . . . a figure completely free of dangerous, haphazard guess-work.

PROCESS ENGINEERING

By William H. Schutt, Industrial Designer
308 pages, 58 blueprints, 18 charts, $4.00

This manual is *so thorough—so down to earth*—that any man familiar with the fundamentals of blueprint reading and time and motion study can easily follow the proven procedures outlined . . . can quickly acquire the advanced professional knowledge to qualify for a position as process engineer in any machine shop, large or small.



PROCI

You get detailed, practical guidance on—

- How to establish the proper sequence of operations and exact labor costs directly from the blueprint
- How to determine the quantity and cost of material to be used
- How to plan efficient tools, dies, jigs, and fixtures for economical production

Don't delay—mail coupon today for your copy

CONTENTS

1. Estimating
2. Power Presswork
3. Drawing Operations
4. Determination of Drawing Operations
5. Drawing Pressures and Presses
6. Visualizing Movements
7. Tool and Die Cost and Construction
8. Brace
9. Control Plate
10. Windshield - Division Molding
11. Regulator Plate
12. Locking Clip
13. Indicator Hand
14. Locking Clip Guard
15. Roller Assembly
16. Shaft
17. Toggle Clip
18. Tie Rod
19. Inlet Valve Guide
20. Throttle Body
21. Camshaft Hub
22. Distributor Base

McGraw-Hill Book Co., 330 W. 42nd St., New York 18

Send me Schutt's **Process Engineering** for 10 days' examination on approval. In 10 days I will send $4.00 plus few cents delivery charges, or return book postpaid.*

Address .....

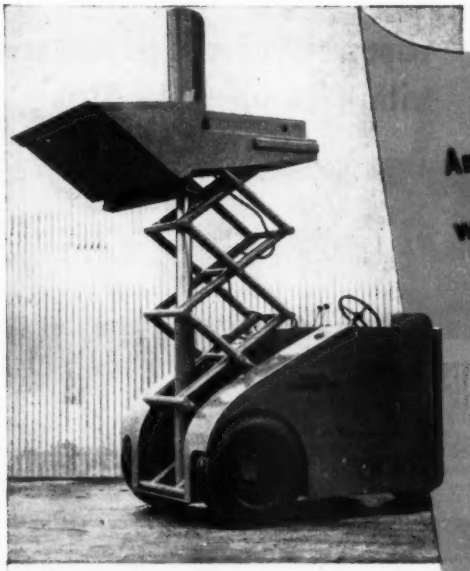
Name .....

City and State .....

Company .....

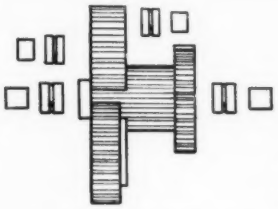
Position PE-1-49

We pay mailing costs if you send cash with this coupon. Same return privilege.

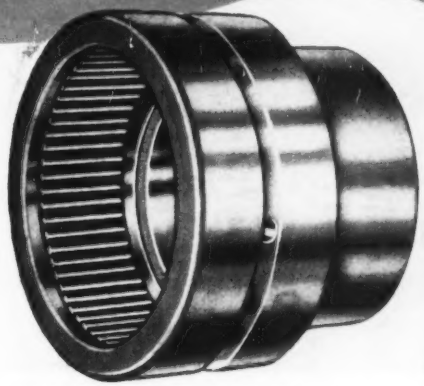


Another typical design problem where "small space requirements" are solved by

ORANGE ROLLER BUSHINGS



● In designing the Reversing Reduction Gear Box of WAGNERMOBILE FOLDAWAY LIFTS and SCOOPMOBILES, engineers of Mixermobile Manufacturers, Portland, Ore., sought the highest anti-friction protection within very limited space. This was obtained by using two Orange Roller Bushings on the Idler Gear and two in the Gear Cluster. These Lifts have a capacity of 6,000 lbs. to 8 ft., 4,000 lbs. to 11 ft.



The goal of every design engineer is to simplify his product, to make it more compact, while improving its performance.

You'll find a great help in Orange Roller Bushings. Use them wherever you need highest anti-friction protection for rotating or oscillating parts. Orange Roller Bushings carry high loads with very small space requirements. They run smoothly, quietly—give long, trouble-free operation in all kinds of service.

One of the outstanding features of Orange Roller Bushings is the closer internal running clearances which minimize the possibility of misalignment of rollers while running. Other features are the extreme standards of precision in heat-treating, finishing and inspection—efficient lubrication—and ample overload margin. Consult with our engineers on any bearing application without obligation.

WRITE FOR ENGINEERING DATA BOOK which shows construction, sizes, capacities, load factors, installation data, etc.

ORANGE ROLLER BEARING CO., INC.
551 Main Street, Orange, N. J.

Mail Coupon for Engineering Data

Orange Roller Bearing Co., Inc., P E
Orange, N. J.

Please send me your Roller Bushing Data Book

Name _____ Title _____

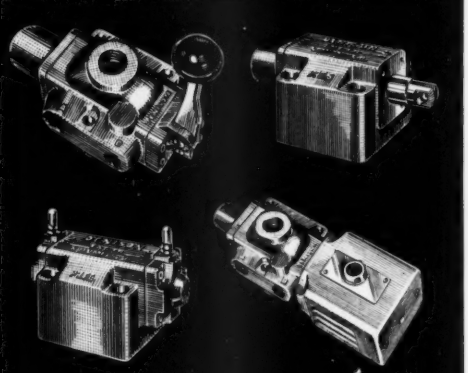
Company _____

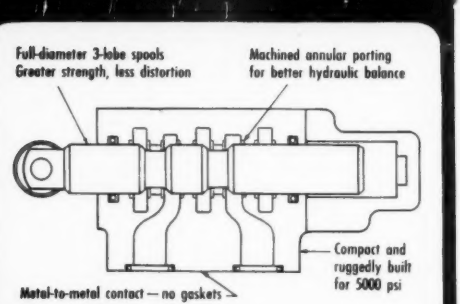
Address _____

City _____ State _____

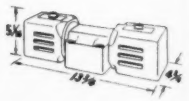
LONGER SERVICE
is built into DENISON hydraulic 4-way VALVES

Provided in two types — either threaded or subplate
Complete range of pipe sizes — from ¼" to 1½"





COMPACTNESS:
Check dimensions of the Denison ¾" double-solenoid valve shown at right, with those you are now using.



COMPARE:
Denison Valves with *any* valves on the market today. Compare them for space-saving size; lasting efficiency; modern, rugged construction; low cost. Send for bulletins VD-1 and VD-2 without delay!

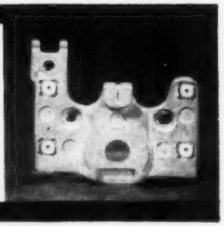
The DENISON Engineering Co.
1157 Dublin Road Columbus 16, Ohio

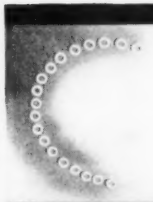
DENISON EQUIPMENT for APPLIED Hydraulics

HOW TO
Improve Product Performance with NYLON Rod and Strip

GEARS machined from Nylon Rod have excellent wear resistance, operate quietly and do not require lubrication.

BUSHINGS for tuning devices are machined from Nylon Rod, staked into place and tapped. They have the toughness to withstand staking and the heat resistance that gives long product life.





WASHERS for holding commutator segments are stamped from Nylon Strip at minimum tooling cost. Use of nylon permits reduction in size without loss of strength, and gives heat resistance to withstand nearby soldering during assembly.

ROLLERS for aircraft use are made from Nylon Rod for a number of reasons: light weight, wear resistance, good frictional properties.

For economy along with product improvement, think about these advantages you get with Nylon Rod and Strip.

You *eliminate the need for costly molds* on short run jobs. You save time in production, with nylon that is *easy to machine or stamp*. And you avoid long waits for new molds when designs are changed.

Free Folder of Useful Engineering Data

A note on your company letterhead will bring you this folder containing useful data on the physical properties and fabricating characteristics of Nylon Rod and Strip, available in several formulations.

the POLYMER CORPORATION of PENNSYLVANIA

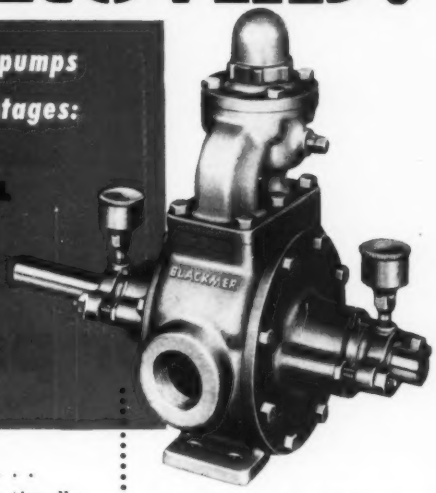
201 GANSTER BUILDING, READING, PENNSYLVANIA

BLACKMER PUMPS are . . .

Performance PROVED!

You get better service from Blackmer pumps because of these proved-in-use advantages:

- ASSURED CAPACITY
- POSITIVE PRESSURE CONTROL
- SELF-ADJUSTING FOR WEAR
- MINIMUM MAINTENANCE
- HIGH SUCTION LIFT
- LONG SERVICE LIFE
- ECONOMICAL OPERATION



MODEL 1203: Pump with removable liner. Made in capacities from 10 to 750 GPM. For general industrial use. Handles pressures to 100 PSI and liquids up to 600° F.

What do ***you*** look for in a pump? Dependability? . . . All Blackmer pump parts are designed with an exceptionally high factor of safety for ***extra*** dependability. Rated capacity? . . . Blackmer pumping elements which are self-adjusting for wear assure continuous full delivery. Elimination of costly shutdowns? . . . Simplicity of Blackmer design makes maintenance quick, easy and inexpensive. Blackmer performance, sturdiness and economy have been ***proved-in-use.*** Make your own comparisons. Get ***all*** the facts. Telephone your Blackmer representative, or write:

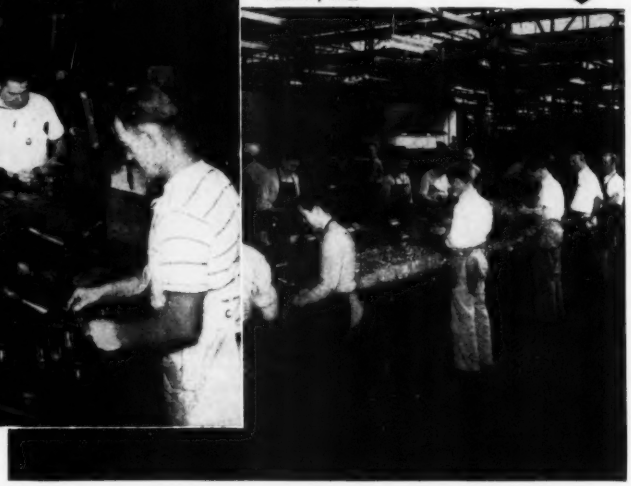
BLACKMER PUMP COMPANY, Grand Rapids, Michigan

BLACKMER PUMPS
Self-Adjusting for Wear

Power Pumps • Dry Cleaning Pumps • Sanitary Pumps • Truck Pumps • Strainers • Hand Pumps

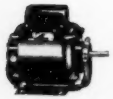
Methods Engineering specifies the exact tools required, from the Tool and Die Section, for the production of each individual type motor.

The focal point for concentration of all precision-built component parts is the Final Assembly Line.



If you could lease a motor production line

. . . you would still need the knowledge and skill available in Emerson-Electric *Twin-gineering*

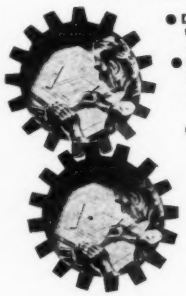


1/20 to 5 H.P. AC and DC

You actually engage more than the necessary production facilities when your motor order is *Twin-gineered* at Emerson-Electric. The *meshing* of your engineering minds with ours, in the planning stages—the combining of your product "know-what" with our motor design "know-how"—results in a power application that gives the product top operating efficiency. To produce such an order, an Emerson-Electric Application Engineer becomes your Project Engineer. Working for you, he co-ordinates the work of the specialists who accomplish the necessary design, tooling, set-up, production and testing of your motors. The result is often the complete conversion of a distinct portion of our facilities to your requirements . . . an extension of *your* plant, but utilizing *our* knowledge, skill and experience.

Your inquiry is invited on the advantages *Twin-gineering* offers in saving you costly engineering "back-tracking" . . . in providing a dependable power application that means so much to the market success of your appliance or equipment.

Here's now TWIN-GINEERING *"follows through"* to give you the perfect power application:

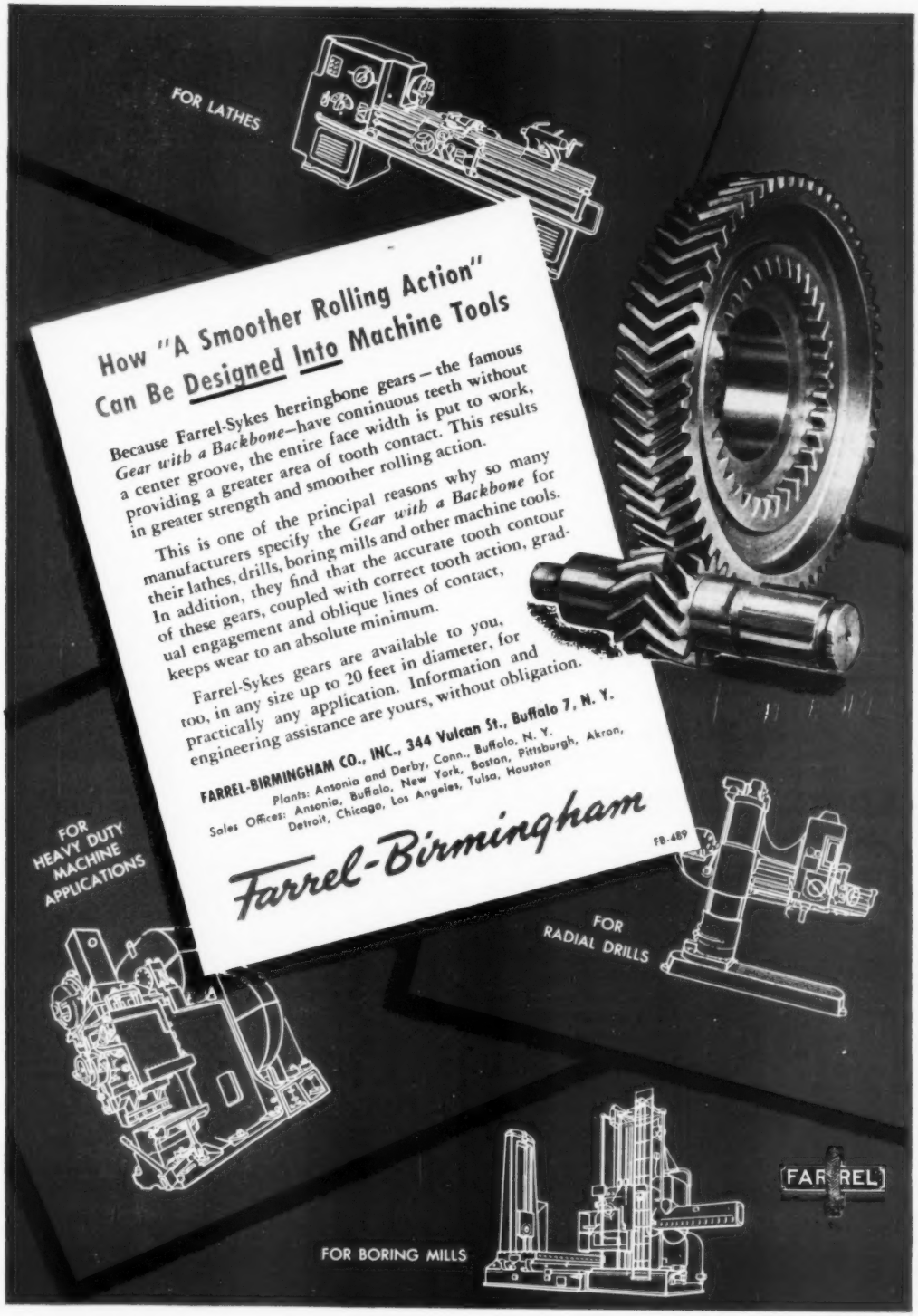


- **DESIGN SERVICE:** Our "draft board," in consultation with your own engineers, plans the best power application for your particular need.
- **PRODUCTION:** An Emerson-Electric Application Engineer, assigned to each project, personally directs the writing of specifications and performance requirements, from which production is planned.
- **QUALITY CONTROL:** Rigid testing of both materials and motors is carried out by inspectors in accordance with instructions established by the Application Engineer.
- **DELIVERY AND ORDER CONTROL:** With the benefit of adequate facilities, production of your order is handled on a predetermined delivery schedule, geared to your requirements.
- **FIELD LIAISON:** The Emerson-Electric Territorial Representative, provides direct liaison on all phases of the power application, from inception to final delivery and marketing of the product.

THE EMERSON ELECTRIC MFG. CO.
ST. LOUIS 21, MO.

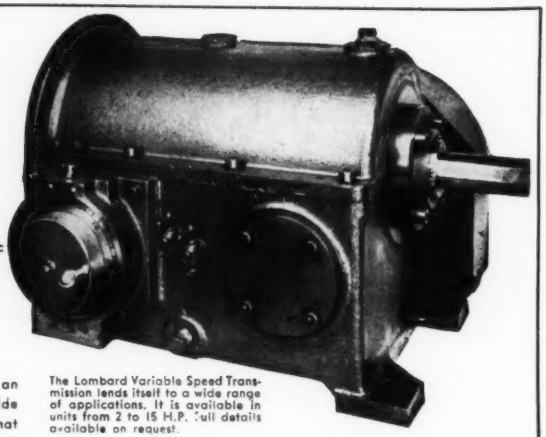
EMERSON ELECTRIC

MOTORS · FANS — APPLIANCES


FOR LATHES
How "A Smoother Rolling Action" Can Be Designed Into Machine Tools
Because Farrel-Sykes herringbone gears – the famous *Gear with a Backbone*–have continuous teeth without a center groove, the entire face width is put to work, providing a greater area of tooth contact. This results in greater strength and smoother rolling action.
This is one of the principal reasons why so many manufacturers specify the *Gear with a Backbone* for their lathes, drills, boring mills and other machine tools. In addition, they find that the accurate tooth contour of these gears, coupled with correct tooth action, gradual engagement and oblique lines of contact, keeps wear to an absolute minimum.
Farrel-Sykes gears are available to you, too, in any size up to 20 feet in diameter, for practically any application. Information and engineering assistance are yours, without obligation.
FARREL-BIRMINGHAM CO., INC., 344 Vulcan St., Buffalo 7, N. Y.
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Detroit, Chicago, Los Angeles, Tulsa, Houston
Farrel-Birmingham
FB-489
FOR HEAVY DUTY MACHINE APPLICATIONS
FOR RADIAL DRILLS
FOR BORING MILLS
FARREL

THE NEW LOMBARD TRANSMISSION

. . . for applications requiring infinite variation in speeds



The Lombard Variable Speed Transmission lends itself to a wide range of applications. It is available in units from 2 to 15 H.P. Full details available on request.

By incorporating the Lombard Variable Speed Reducer as an integral part of equipment, it is possible to provide a wide range of easily controlled useful speeds. Design is such that a speed range of greater than 20 to 1 can be obtained with a minimum speed approximating zero.

Power is transmitted in a straight line from input to output shafts, thereby assuring convenient application. A planetary speed reducing unit combined with the output shaft and mounted in a steel cage provides great rigidity and assures perfect alignment of gearing. All gears are enclosed and run in oil.

SEND FOR NEW CATALOGUE

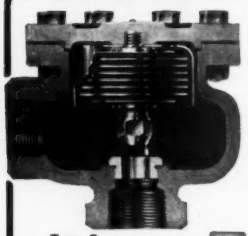
LOMBARD GOVERNOR CORPORATION

Ashland, Massachusetts

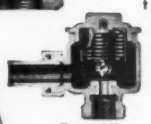
We Invite You

TO TEST NICHOLSON STEAM TRAPS FOR

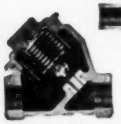
LOWEST STEAM LOSS ➔LARGEST CAPACITY



Type C



Type AU



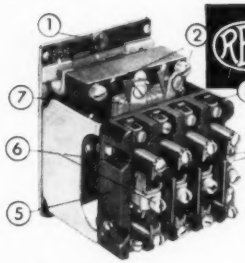
Type AHV

See why an increasing number of America's leading plants are standardizing on Nicholson traps.

Comparative tests by large trap users show: record low for steam waste; 2 to 6 times average drainage capacity; operate on lowest temperature differential; no freeze-ups; greater simplicity (fewer spare parts). 5 types for every purpose; size ¼" to 2"; pressures to 225 lbs. Test trap gladly sent. BULLETIN 1047.

W. H. NICHOLSON & CO. 200 OREGON STREET WILKES-BARRE, PA.

Valves • Traps • Steam Specialties



RBM INDUSTRIAL CONTACTORS

2 TO 8 POLE
600 VOLT A. C.
10—15 AMPERE SIZES
REVERSING—NON-REVERSING TYPES
INTERCHANGEABLE CONTACTS

1. Heavy steel base.
2. Coil readily replaced by removing 2 heavy screws holding E-shaped magnet frame.
3. Accessible solderless type terminals are conveniently located. All line terminals at top; load terminals at bottom.
4. Any pole can be changed from normally open to normally closed, or vice-versa, without additional parts.
5. Melamine stationary contact block and movable contact carrier.
6. Stationary and movable contacts can be readily replaced with use of screw driver only and without removing wiring.
7. Vacuum impregnated magnet coil designed for continuous 50/60 cycle service.

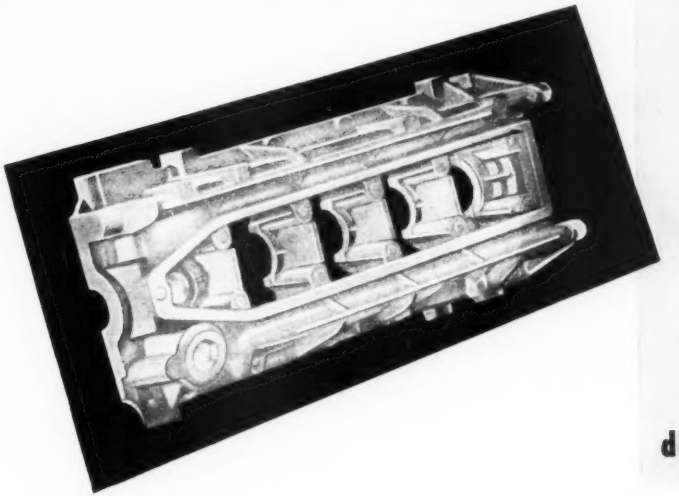
For descriptive bulletin No. 600 write Dept E-1

R-B-M DIV., ESSEX WIRE CORP.
LOGANSPORT, INDIANA

RBM

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

This Aluminum Casting... had to have



37,000 lbs. Tensile Strength
23,000 lbs. Yield Strength
—plus corrosion resistance and dimensional accuracy

A typical parts problem solved with the help of *Permite Aluminum Engineers*

You know the properties you need in your aluminum castings — the precise tensile strength, yield strength, ductility, corrosion resistance, etc. — also your requirements as to cost, quantity, and design.

You can be certain of obtaining castings that meet these requirements when you bring your parts problem to Permite engineers . . . specialists in the aluminum casting field. They can help you select from the great number of modern aluminum alloys available, the one alloy that will assure the results you want.

Our technicians can also suggest the most efficient casting method — sand mold, semi-permanent mold, die cast, or the Permite Permanent Mold Process which produces precision castings of finer grain structure, greater strength and hardness, dimensional tolerance as close as ± .010".

Even before a casting is in the blue-print stage, cooperation between Permite engineers and your own organization can prove very helpful to you. Write us about your parts problem . . . or, send drawings for recommendations and estimate.

PERMITE

ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

PROTECTION *for air operated equipment*

• *For primary pressures to 150 p.s.i. Any reduced pressure from 5 to 125 p.s.i. Sizes ⅜" and ½".*

HERE is the new air pressure regulator that gives you everything you want for control and protection of air operated equipment.

NO DANGER OF PRESSURE BUILD-UP. Thanks to the automatic safety relief feature of Hannifin's "Air Warden" valve design. No pressure build-up above setting of regulator even if valve is accidentally prevented from seating tight.

SAVES AIR. Easy to "back off" pressure without exhausting control valve. No air lost except excess pressure.

SAVES TIME. Speeds up operating cycle where intermittent pressure is used. Less time needed for pressure build-up.

PRECISION CONTROL. Instrument type adjusting knob. Precision construction throughout. Write for the full story.

HANNIFIN CORPORATION
1101 S. Kilbourn Ave. Chicago 24, Illinois

HANNIFIN

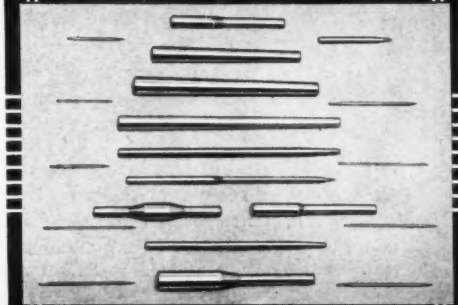
PRESSURE REGULATORS
FILTERS • LUBRICATORS

Sier-Bath
GROUND or SHAVED
Gears
...for lower maintenance costs

Greater accuracy in gears means lower maintenance costs in the upkeep of the machine. Sier-Bath is equipped with the latest, most efficient machinery for shaving spiral and spur gears up to 24" diameter and for grinding spur gears to 16", spiral gears to 10", splined shafts (both straight side and involute) to 42" long. Send your specs to Sier-Bath.

Sier-Bath
GEAR and PUMP CO., Inc.
9262 HUDSON BOULEVARD NORTH BERGEN, NEW JERSEY

MADE TO ORDER



Tubes, Rods, Wire reduced by rotary swaging to your specifications by the pioneer rotary swaging machine builder.

Cuts show various tubes reduced, tapered and closed on end by swaging. Solid work up to ⅝" diameter and medium wall tubing up to 2½" O. D. can be handled.

You benefit from our nearly seventy years' rotary swaging experience.

The Torrington Company
SPECIALTY DEP'T.
Torrington, Conn., U.S.A.

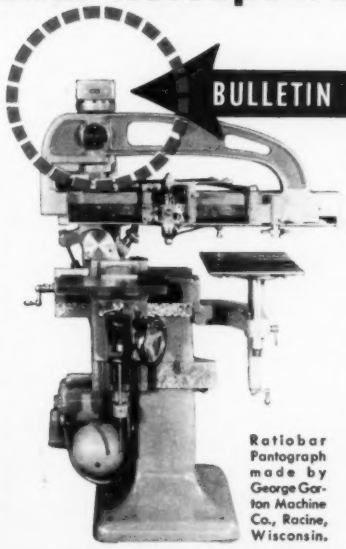
Open view of enclosure for surface mounting.

Switch unit without enclosure for machine bases.

Closed view of enclosure for surface mounting.

Bulletin 600 Switch fits into any standard switch box.

Starting Switches with Overload Protection for Fractional Horsepower Motors



BULLETIN 600 STARTING SWITCH

Ratiobar Pantograph made by George Gorton Machine Co., Racine, Wisconsin.

To satisfy the latest ruling of the National Electrical Code... which requires overload protection for many fractional horsepower motor applications... the Bulletin 600 Starting Switch is the popular answer.

Its self-contained thermal breaker is always dependable. Long periods of inactivity will not affect its accuracy. At the first sustained overload... the switch trips... and the motor is protected against burnout.

Waterproof Enclosure.

The Bulletin 600 Starting Switch cannot be held closed until the overload condition is corrected. This compact control unit is a sales asset to any machine.

Above is shown how easily the Bulletin 600 Fractional Horsepower Starting Switch fits into the standard Allen-Bradley enclosure or into any standard switch box.

The switch unit can also be mounted in any suitable cavity in the machine frame.

For locations requiring enclosures to operate in wet or hazardous locations, there are several standard A-B enclosures to meet every service requirement.

Bulletin 600 Switches are available with pilot lights, selector switches, and other accessories. Send for complete data, today.

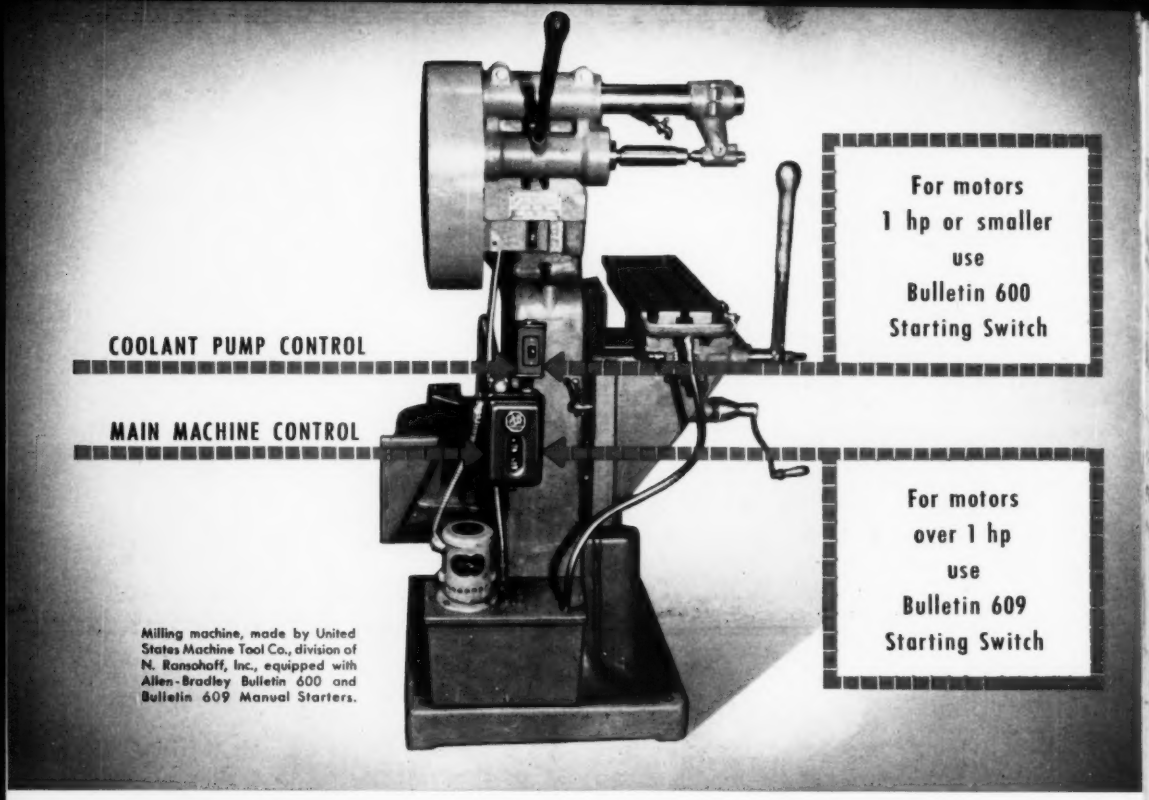
ALLEN-BRADLEY

QUALITY

BULLETIN 600 STARTING SWITCHES

A-B Quality

Allen-Bradley Co.
1316 S. Second Street
Milwaukee 4, Wis.



Milling machine, made by United States Machine Tool Co., division of N. Ransohoff, Inc., equipped with Allen-Bradley Bulletin 600 and Bulletin 609 Manual Starters.

HOW TO PICK THE RIGHT MANUAL STARTER

For Motors of 1 hp or less—Specify the compact Allen-Bradley Bulletin 600 Manual Starting Switch. It is so small that it fits easily into any standard conduit switch box . . . with ample wiring space.

A self-contained thermal overload breaker trips the switch when the motor is overloaded. The switch cannot be reclosed until the overload condition is corrected. A full line of enclosures is available for every service application.

Bulletin 609 Starter in steel enclosure. Note white interior and the ample wiring space.

For Motors of 1-5 hp, 220 v—1-7½ hp, 600 v Specify the popular Allen-Bradley Bulletin 609 Manual Starter, available in enclosures for general, waterproof, dust-tight, and hazardous locations.

Quick-make and quick-break silver alloy contacts . . . double overload breakers . . . and handy push-button operation are a few of the assets of this popular manual starter. Available also for mounting in machine bases.

Send for Third Edition of Allen-Bradley Condensed Catalog . . . . just off the press.

Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY
MANUAL AND AUTOMATIC MOTOR CONTROLS
QUALITY

A-B Quality

New kind of bushing stock . . .
***your key* to new savings!**

HERE'S WHY. Shenango-Penn tubular bushing stock is *different!* It's *centrifugally* cast! Now, in a complete range of stock sizes, ready for immediate delivery, Shenango-Penn bars offer you those *same* money-saving qualities that make Shenango-Penn a preferred source of supply for special bearings, bushings and sleeves that must withstand the toughest kinds of service.

ADVANTAGES. The Shenango-Penn *centrifugal* method produces pressure-dense bars having exceptionally fine grain, higher tensile strength, finely divided and uniform lead dispersion, greater elongation, and *complete* relief from sand inclusions and blow holes. So naturally you can count on fewer rejects, excellent bearing load distribution, superior wear-life, and less chance of breakage or distortion in service.

FREE BULLETIN. Send for Bulletin No. 145 containing additional information and the complete list of standard, conveniently stocked sizes. These bars are ready now to give you that big *extra* margin of safety, service-life and over-all economy.

SHENANGO-PENN MOLD COMPANY
675 WEST THIRD STREET • DOVER, OHIO
Executive Offices: Pittsburgh, Pa.

SHENANGO-PENN

ALL BRONZES • MONEL METAL
NI-RESIST • MEEHANITE METAL®

GOOD SEATING

Improves Performance . . .

The seats shown above represent part of the standard Milsco stock seats. If your equipment requires seating of a special design, we will be glad to have our Engineering Department work with your engineers in constructing seats adaptable to your equipment. Write today . . . for better riding tomorrow.

MILSCO MFG. CO.
2730 North Thirty-third Street
Milwaukee 10, Wisconsin

MILSCO "COMMANDER"
. . . . a seat designed to give the operator exceptional comfort and ample leg room. Frame is made of heavy steel tubing. Removable cushion is padded with FOAM RUBBER, with a choice of covering materials. Complete with padded backrest.

MILSCO "JUNIOR" BUCKET SEAT
. . . . the popular-size bucket seat, with new improved features. Heavy steel base, padded with FOAM RUBBER, rolled edge. Simple to install with the new Milsco Ventilatiop-Drain channel. Comes complete with attaching bolt which is inserted through this channel as a simple assembly operation. Can also be had with backrest.

MILSCO *NEW* SENIOR SEAT
. . . . The new Milsco Senior seat is the last word in operating comfort. The Milsco Senior gives additional support where it is needed most to assure safer operating efficiency. Padded with FOAM RUBBER, complete with the Milsco Drain-Ventilation channel for quick installation.

Comfort . . .
Durability . . .

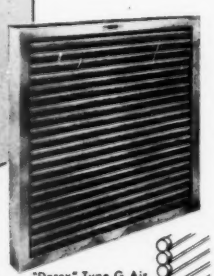
MILSCO CUSHION SEATS

DOREX

RECOVERS FRESH AIR FROM OLD

with

H & K PERFORATED METALS



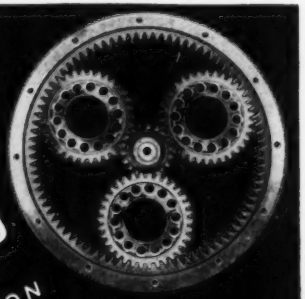
"Dorex" Type G Air Recovery Panel — a product of W. B. Connor Engineering Corp., New York, N. Y.

In the new field of Air Recovery, "Dorex" Air Recovery Panels have found wide acceptance. **H & K Perforated Metals** form the tubes that hold activated carbon granules. By using these panels, air already conditioned is restored to its original freshness, greatly increasing efficiency and lowering costs of present air conditioning, heating and cooling systems. "H & K Perforated" is more satisfactory than other types, says the manufacturer, due to "ease of fabrication, longer life and resistance to corrosion". "H & K Perforated" may be the right answer to your problem, too. A wider variety of sizes, shapes and spacings in nearly every metal as well as plastics, fabrikoids, plywood and other sheet materials.

Write for literature

The Harrington & King PERFORATING CO.

5630 Fillmore Street **Chicago 44, Illinois**



GEARS
OF EVERY DESCRIPTION

This planetary gear train is an example of the precision gear work which we handle to our customers' prints and specifications

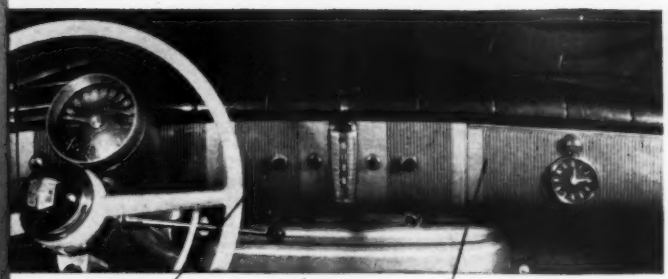
Write Dept. G

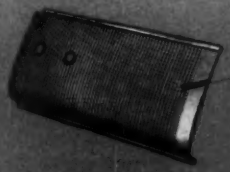
HARTFORD Special

THE HARTFORD SPECIAL MACHINERY CO.
HARTFORD 5, CONN.

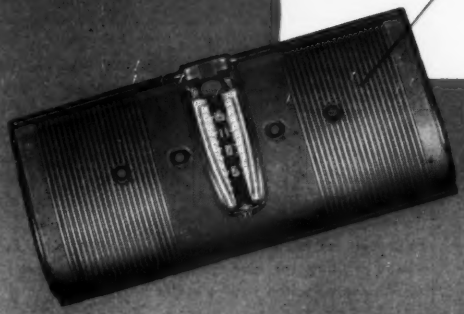
Nash Chose STYRON 637

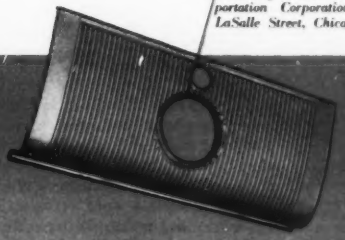
for better light stability and economical adaptability





Molded by General American Transportation Corporation, 135 South LaSalle Street, Chicago 3, Illinois.





The new grade of polystyrene opens vast fields for the adaptation of plastics in the automotive industry. The exceptional quality of Styron 637—improved light-stability—makes it extremely applicable to automotive interior parts.

In the case of the '49 Nash the originally designed instrument panel looked good on paper—But to prove practical, it had to be constructed of a material that was (1) resistant to yellowing in sunlight, (2) adaptable to Nash's new "cockpit control" and (3) economical enough to use on a very large scale. Nash chose Styron 637. The light stability of Styron 637 solved many of the interior designing problems. The low cost and high quality of Styron 637 permitted its use in mass production. Styron, America's number 1 plastic, again has proved itself the right plastic for the right job.

PLASTICS DIVISION, DEPT. T-9

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

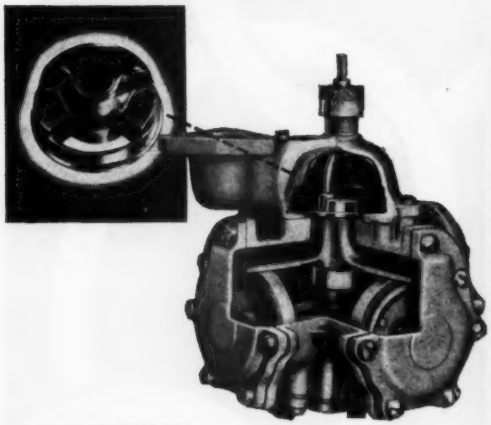
New York • Boston • Philadelphia • Washington • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

DOW

Plastics

PROBLEM:

To supply a rotary valve for gasoline meters that would slash normally high maintenance costs and eliminate inaccuracy in meter measurements.



SOLUTION:

Morganite developed and tested a self lubricating rotary valve suitable for gasoline metering. Tests indicated a 90% reduction in operating troubles due to friction, gumming or sticking.

MORGANITE
SELF-LUBRICATING
LIQUID METER VALVES

See our CATALOG in SWEET'S FILE

FOR DETAILED INFORMATION consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel or specific proposals call Morganite

Placed in actual service, results were even better than anticipated. Sticking and friction caused by wax and gumming deposits—the cause of inaccurate measurement and service failures—were reduced to the vanishing point. Morganite dry lubrication is effecting savings and solving "insoluble" problems in all phases of the mechanical, electrical and processing industries.

REGISTERED TRADE MARK

Morganite INCORPORATED

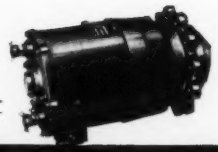
LONG ISLAND CITY 1, NEW YORK

Self-lubricating valve for residential meters operates silently without metallic click or resonance.

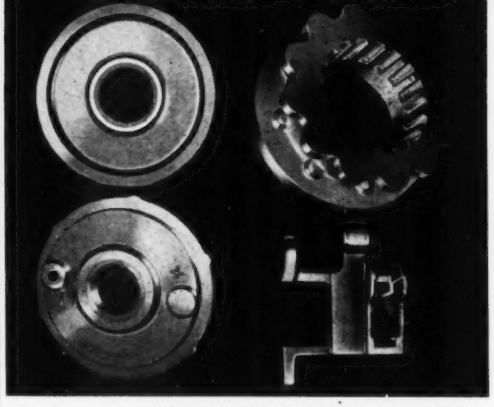
Wobble plate for liquid meters operates under continuous flow, free from sticking and corrosion

Manufacturers of Morganite Carbon Brushes for all meter and generator applications, and Morganite Carbon Piles.

WESTINGHOUSE AIRCRAFT GAS TURBINE STARTER USES



OHIO PRECISION
PLASTER MOLD CASTINGS
for CLOSEST TOLERANCE
SMOOTH SURFACE • REAL ECONOMY



PHOTOGRAPHS COURTESY OF WESTINGHOUSE ELECTRIC CORPORATION

• Ohio Precision quickly solved the production problem on the four parts shown above. Westinghouse sent prints and specifications and asked for a quotation. OPC furnished favorable cost figures in a hurry. Result: Ohio Precision produces regular quantities of these smooth, super-accurate plaster mold castings. Ohio Precision can solve problems, save time and money for you, too. Here's how: **1.** When sand castings won't meet specifications. **2.** When quantities are too small to warrant expensive dies. **3.** When you're waiting for dies and in a hurry for parts. When machine production wastes metal.

OHIO PRECISION FEATURES

CLOSEST WORKING TOLERANCE
plus or minus .005 of an inch

NO MIS-MATCH TOLERANCE
Ohio Precision makes them match

SMOOTH FINISH
minimizes costly machine work

MANY AVAILABLE SIZES
up to 8" wide, 10" long, 8" high

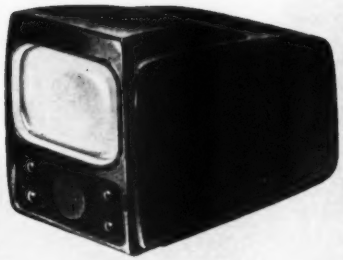
ADAPTABLE AND REASONABLE
saves expense of costly dies for experimental work

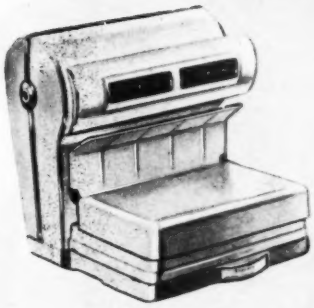
FOR COMPLETE COST FACTS, SEND PRINTS AND SPECIFICATIONS TODAY!

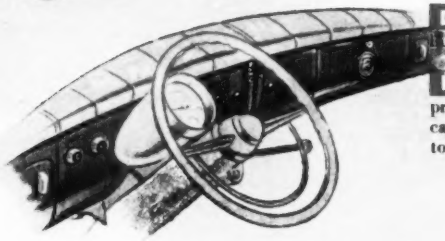
OPC

OHIO PRECISION CASTINGS, INC.
109 Webb St., DAYTON 3, OHIO
Plaster Mold Castings Made From Brass • Bronze • Aluminum • Beryllium Copper

GENERAL AMERICAN MOLDS PLASTICS FOR AMERICA'S LEADING INDUSTRIES







Perhaps plastics can improve your product or some part of your product. Plastics can often add new beauty and sales appeal ... cut costs ... speed production ... perform many functions more efficiently. Consult General American about your plastics problems.

CUSTOMERS Leaders in these industries: Automotive, furniture, washing machine, refrigerator, radio, television, industrial specialties, electrical appliances.

PRODUCTION General American produces parts and products as small as screw cap pilot lights and as large as complete television cabinets. General American's engineers are constantly developing practical, new applications for plastics.

SPECIAL SERVICES Facilities for assembling of parts and products, painting and special handling wherever necessary.

DIES Dies may be supplied by customers or built in General American's complete die shops.

EQUIPMENT Large batteries of high speed presses, including injection presses of 2 to 48 oz. capacity and compression presses from 100 to 2000 tons (with 71" x 74" platen areas).

At General American you benefit from more than 40 years of precision production experience.

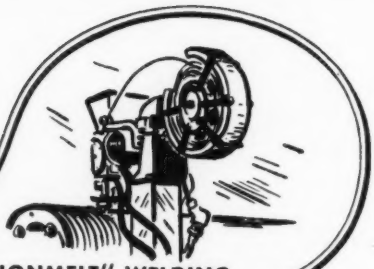
Plastics Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

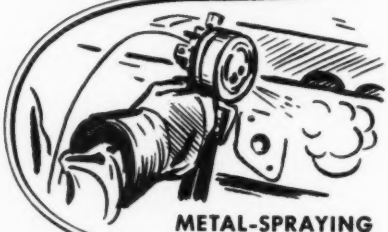
New York, 10 East 49th Street • 135 So. LaSalle Street, Chicago 90, Illinois • *Los Angeles, Richfield Building*

HASTELLOY TRADE-MARK *Alloy Wire*

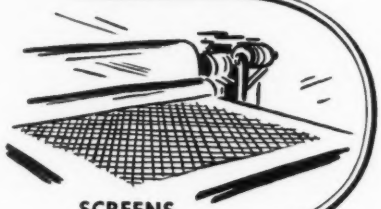
FOR METAL-SPRAYING, WELDING, and FABRICATED WIRE PRODUCTS



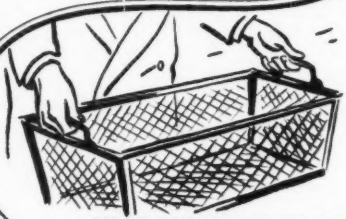
"UNIONMELT" WELDING



METAL-SPRAYING



SCREENS



HEAT-TREATING BASKETS

HASTELLOY nickel-base alloys, in the form of drawn wire, are available for the fabrication of corrosion-resistant screen, cloth, and baskets. The wire is also excellent for metal-spraying and for many types of automatic welding and hard-facing.

HASTELLOY alloys have a tensile strength comparable to that of the high-strength alloy steels, and possess unusual strength even at elevated temperatures. These alloys are specially designed to withstand the most severe conditions of chemical corrosion. Nickel-molybdenum alloy B is particularly resistant to hydrochloric and sulphuric acids, many organic acids, and all alkalies. Alloy C, a nickel-molybdenum-chromium-tungsten-iron composition, has excellent resistance to strong oxidizing agents, such as ferric chloride and wet chlorine, and is outstanding in its resistance to brine and salt spray.

In addition to HASTELLOY alloy wire, you can also obtain wire made of MULTIMET alloy—a cobalt-chromium-nickel composition developed for service at elevated temperatures.

Cut and straightened lengths or coils, in diameters down to 0.060 in., can be obtained directly from Haynes Stellite Company, Kokomo, Indiana. Wire in diameters less than 0.060 in. down to 0.002 in. is available from an associate company, Kemet Laboratories Company, Inc., Madison Avenue and West 117th Street, Cleveland 1, Ohio. For more complete information, write for a copy of the booklet, "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys."

HAYNES TRADE-MARK *Alloys*

The terms "Haynes," "Hastelloy," "Multimet" and "Unionmelt" are trade-marks of Units of Union Carbide and Carbon Corporation.

Haynes Stellite Company

Unit of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

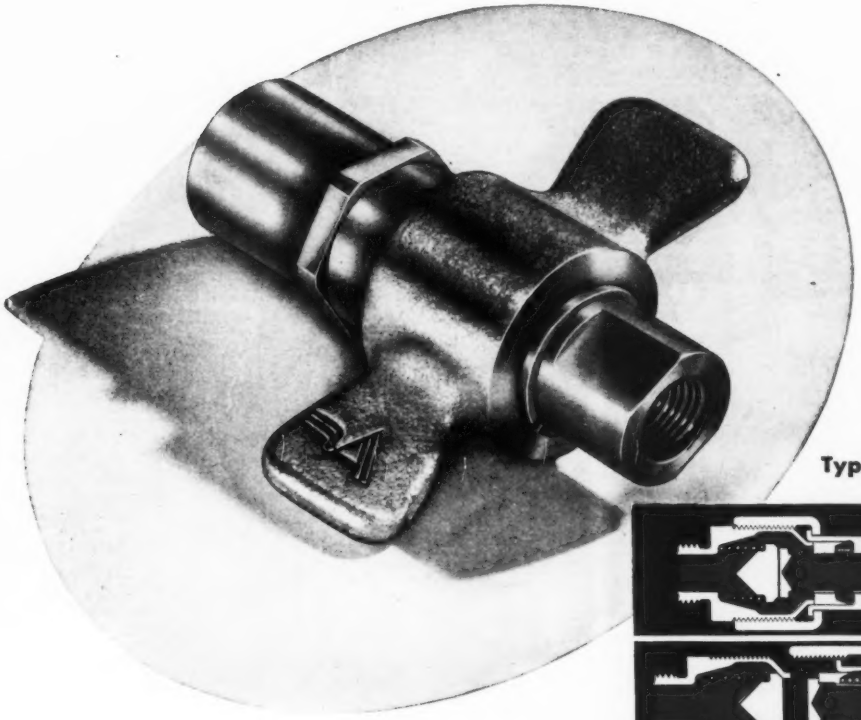
Sales Offices

Chicago—Cleveland—Detroit—Houston

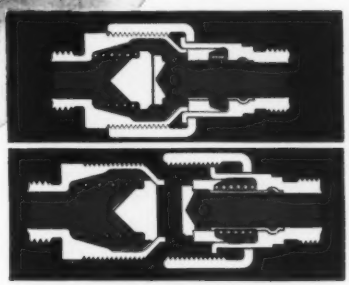
Los Angeles—New York—San Francisco—Tulsa

Aeroquip

SELF-SEALING COUPLINGS



Type 5100



With the installation of Aeroquip Self-Sealing Couplings, fluid-carrying lines can be disconnected without loss of liquid or inclusion of air upon reconnection. Cooling units can thus be exchanged or serviced in less time, without discharging the lines.

Aeroquip Self-Sealing Couplings are suitable for lines carrying hydraulic fluids, oils, fuels, coolants or refrigeration gases. Write for further details.

Aeroquip for better performance, maintenance and service

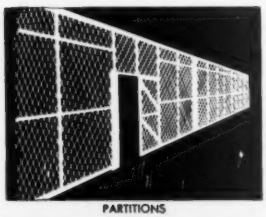
AEROQUIP CORPORATION

JACKSON, MICHIGAN

303 Warnham Bldg., Hagerstown, Md. • 2912 N.E. 28th St., Fort Worth, Texas • 1051 North Hollywood Way, Burbank, Cal. • 1410 2nd Ave. So., Minneapolis 4 • In Canada: 72-74 Stafford Street, Toronto, Canada

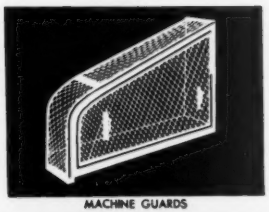
Aeroquip Products are Fully Protected by Patents in U. S. A. and Abroad

Penmetal EXPANDED METAL



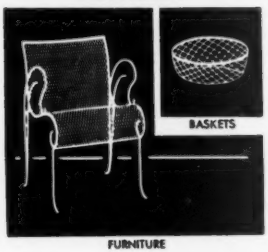
PARTITIONS

Unsurpassed for its more familiar heavy duty uses for reinforcing, for partitions, shelving and other exposed or covered work, PENMETAL EXPANDED METAL is now finding new applications in equipment and products where light weight, strength and beauty are desired.



MACHINE GUARDS

Machine guards, grilles, doors, panels, furniture, baskets, display racks, toys — literally hundreds of new uses are constantly developing.



BASKETS

FURNITURE

Available in large or small mesh, heavy or light gauge metal, ready to polish, paint or plate — there may be a use for expanded metal in your plant or in your product, to save time, money or both.

Our EXPANDED METAL booklet shows many present uses, and may suggest profitable ones for you. May we mail a copy to you?

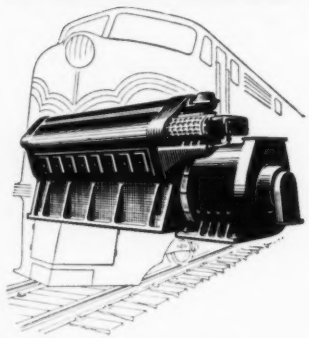
80th PENMETAL YEAR

PENN METAL COMPANY, INC.

General Sales Offices: 205 East 42nd Street, New York 17, N. Y.

District Sales Offices

Boston . New York . Philadelphia . Chicago . Detroit . Indianapolis
Seattle . Los Angeles . San Francisco . Dallas . Parkersburg, W. Va.
Exeter, Pennsylvania, W. Va.



dieselization

Diesel engines in railroad locomotives are piling up an enviable trouble-free performance record. Many castings in these engines contain specified Molybdenum contents.

When wear or heat must be resisted, and high strengths are required, the use of Molybdenum in cast iron is becoming more and more routine.

The listing of a cylinder liner for Diesel use in railroad locomotives containing 3.20% Carbon, 1.90% Silicon, 0.85% Manganese, with 0.20% Chromium, 0.40% Molybdenum and 0.45% Nickel added can be found on page 10 of our new booklet—"Applications of Molybdenum Cast Irons."

Dozens of other alloy cast iron compositions used in Diesel engines, as well as hundreds of other Molybdenum-containing compositions are similarly listed in this new booklet. Write for it!

Climax Molybdenum Company
500 Fifth Avenue
New York City

Please send your FREE BOOKLET "Applications of Molybdenum Cast Irons"

Name.....

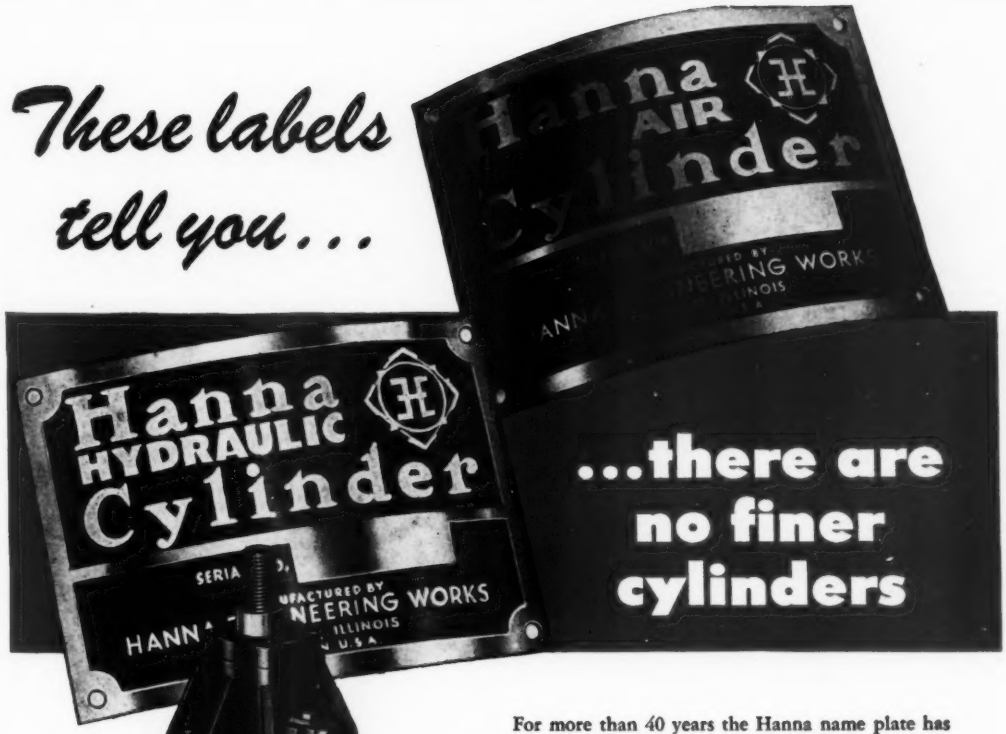
Company.....

Address.....

MOLY

PE-1 F9

These labels tell you . . .



. . . there are no finer cylinders

For more than 40 years the Hanna name plate has been a familiar trademark-of-quality throughout industry. Those who demand the best in cylinder performance, reliability and long life specify Hanna Air and Hydraulic Cylinders for 1001 uses . . . to push, pull, lift, press, clamp or control . . . for the products they build for sale . . . to save manual labor and increase production in their own plants. There are standard Hanna Cylinders to meet most mounting requirements . . . to solve many of *your* problems.

Hanna Air Cylinders are designed for operation up to 110 p.s.i., and to 250 p.s.i. with minor modifications . . . in sizes from 1½" to 20" diameters.

Hanna Hydraulic Cylinders may be operated at working pressures up to 1500 p.s.i. . . . available in a variety of types and capacities.

Send for Hanna Air and Hydraulic Cylinder Catalogs

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1765 Elston Avenue, Chicago 22, Illinois

. . . Are you taking full advantage of Gray Iron's CASTABILITY?

This manifold illustrates the unique castability of Gray Iron in producing complicated integral structures.

Which Characteristics of Gray Iron are Important for Your Product?

CASTABILITY
Rigidity
Low Notch Sensitivity
Wear Resistance
Heat Resistance
Corrosion Resistance
Durability
Vibration Absorption
Machinability
Wide Strength Range

Metallurgists consider Gray Iron the most castable of the ferrous metals. Its high fluidity permits pouring of thin sections and insures accurate reproduction of complicated designs.

The advantage of thus being able to produce an intricate structure in one integral piece is obvious. You avoid the necessity of assembling separate parts, also the machining and fitting of joints.

Every gray iron component you use offers not just one but a combination of important properties not obtainable in other materials . . . *plus ultimate economy.* That is why gray iron is so widely used, so difficult to replace with satisfactory substitutes. Send for free booklet, "GRAY IRON—Its Mechanical and Engineering Characteristics and Details for Designing Cast Components."

Make It Better With Gray Iron

GRAY IRON FOUNDERS' SOCIETY, INC.
NATIONAL CITY BANK BLDG., CLEVELAND 14, OHIO

Idea that turns the heat on sales

And what an idea . . . for something *new* in a cooking range!

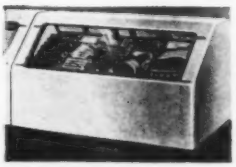
For this smart new gas range is a *heater*, too. Just press a button, turn a valve, and a special unit quickly warms the kitchen on a chilly day!

Again, double-walled Bundyweld* Tubing shares in a bright idea that puts the heat on a manufacturer's sales. For the supply lines and flash and pilot tubes in this sleek appliance are Bundy Tubing, a stand-by in the gas range field.

Whether *you* make toys or trucks, there could easily be an idea in Bundy for you as well. For you'd be amazed at *where* you can use Bundy Tubing.

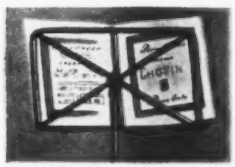
The examples at the right are only *hints*. They range from standard uses for Bundy to possible ways *you* might spark real sales. Look them over now.

1 Push a button and this convertible top *glides* up or down. For its hydraulic pressure lines are strong, dependable Bundyweld* Tubing. Hydraulic brake line systems in 95% of today's cars are **Bundy, too!**

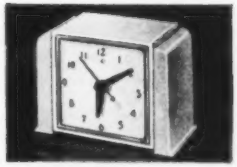


2 Look for Bundy wherever there's refrigeration, as well. Bundy tubing is fast-cooling, easily fabricated, ductile, long-wearing . . . unbeatable for coils, condensers and refrigerant lines where performance counts.

3 One manufacturer uses Bundy as a case and holder for thermometers. Others make awning frames, umbrella stems, spray nozzles of Bundy. Your idea may pay off with a use of Bundy, too. Speaking of ideas . . .



4 It seems as though Bundy would be ideal for strong, light-weight music racks. We don't *know*, but if you're interested we'll be glad to work with you. (Bundy is *already* being used for camera tripods.) Then, too . . .



5 Perhaps clock makers should check on Bundy for hour and minute hand shafts. Ditto meter and gauge manufacturers who need dependable, rugged, tubing parts for all types of precision instruments.

BUNDY TUBING

ENGINEERED TO ★ ★ YOUR EXPECTATIONS ★ ★

*REG. U.S. PAT. OFF.

6 All of the actual Bundy applications shown on this page began with an idea of using Bundy. By the same token, you may easily find the answer to a smarter, lighter-weight, longer-lasting product, turned out more easily and at less cost, through checking Bundy. Why not try. Our engineers will be glad to give you a hand. Just call or write *Bundy Tubing Company, Detroit 14, Michigan.*

WHY BUNDYWELD IS BETTER TUBING

Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong, ductile tube, free from scale, held to close dimensions.

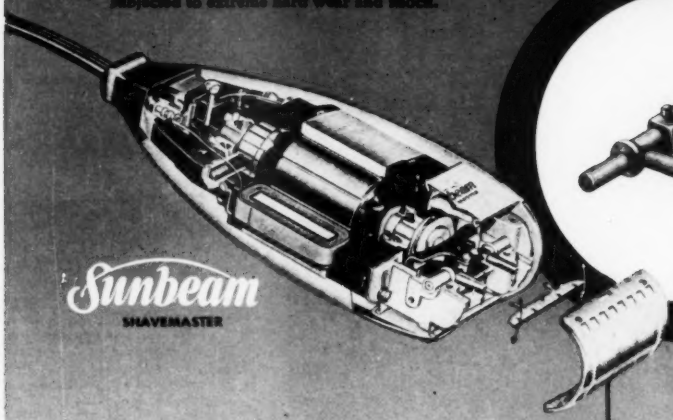
Bundyweld comes in standard sizes, up to 5/8" O.D., in steel (copper or tin coated), Monel or nickel. Special sizes can be furnished to meet your requirements.

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, N.J.:* A.B. Murray Co., Inc., Post Office Box 476 • *Philadelphia 3, Penn.:* Rutan & Co., 404 Architects Bldg. • *San Francisco 10, Cal.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 3628 E. Marginal Way • *Toronto 5, Ont., Canada:* Alloy Metal Sales, Ltd., 881 Bay St. **Bundyweld nickel and Monel tubing is sold by International Nickel Company distributors in all principal cities.**

here's how Microcastings

make possible faster, smoother shaves

The MICROCAST Shaver Shaft is a vital part in the shaving mechanism of the Sunbeam Shavemaster. This device controls a special cutter which speeds over and back in half circle oscillations with six times greater velocity than blades in other shavers do . . . consequently, the Shaver Shaft is subjected to extreme hard wear and shock.



Sunbeam
SHAVEMASTER

MICROCASTING SAVES 3 PARTS

The Shaver Shaft is cast of straight chrome steel eliminating expensive machining costs. Formerly this shaft consisted of three parts . . . *another production case history in which Austenal* MICROCASTINGS *are serving manufacturers by saving them time and money and improving performance of their products.*

Precision Castings From High Melting Point Alloys That Require Little or No Machining—The MICROCAST process offers a flexibility in meeting design problems not possible in the past without pyramiding costs. Small parts of intricate shape can now be specified in a whole new range of high melting point alloys which offer advantages of extreme resistance to heat, wear and corrosion.

NEW CATALOG AVAILABLE

A copy of the new 16 page book, "New Horizons with Microcasting," is yours upon request. It is the most complete report ever published on the subject of the MICROCAST process originated by Austenal Laboratories, Inc. See our catalog in Sweet's File for Product Designers.

MICROCAST PRECISION CASTINGS PROCESS

The name "MICROCAST" is a registered trademark of the Austenal Laboratories, Inc.

MICRO CAST

MICROCAST DIVISION
AUSTENAL LABORATORIES, INC.
224 East 39th Street • New York 16, New York
715 East 69th Place • Chicago 37, Illinois

Install Ross-In-Line for a Full-Flo Line!

THIS

NOT THIS

Full Pipeline Capacity

with lower initial and operation costs...

Yes, these new Ross-In-Line valves fill the bill—a dozen ways in every plant. Solve your "on-and-off" problems. Instant shut-off for plant-wide systems—a single coolant line — or split second control of a single acting cylinder. These air-controlled valves handle pressures 0 to 125 p.s.i.—air, liquid, and gas. Do it better, too, yet at lower cost.

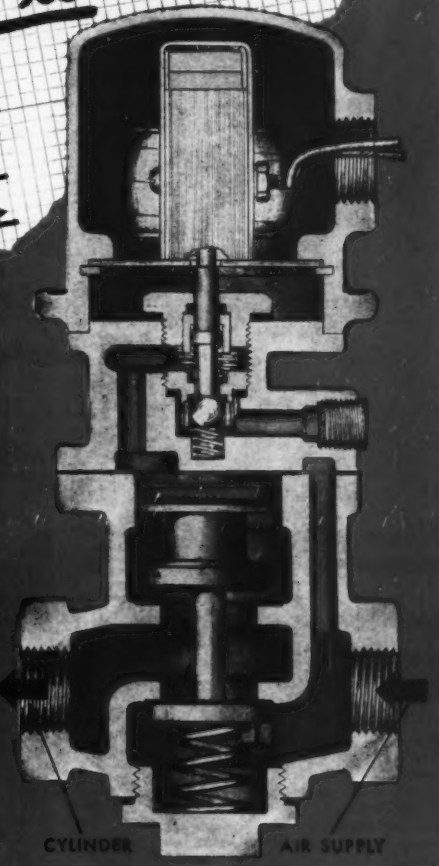
Here's Why...

◆ FULL LINE CAPACITY . . . Full Flo design provides full pipe size opening throughout valve. Eliminates "pinching" of line, reduces friction loss.

◆ LOWER FIRST COST . . . More capacity—therefore more efficiency—per dollar. Quick, easy, straight line installation. No mounting brackets.

◆ LOWER OPERATING COST . . . Only four moving parts, all non-corroding. Inspection without removing from line. Solenoid consumes only .2 amps. holding and 1.2 inrush at 110 v. 60 cy. Interchangeable pilot section simplifies service, decreases inventory.

Designed and built to stand up, seals are Hycar, other parts naval brass and stainless steel. Created specifically for efficient air operated control, straightway and 3-way, normally open or closed, ¼" to ¾" FULL FLO pipe capacity. As a dependable answer to your valve problems, Ross offers this latest addition to a line of over 500 quality valves designed for every phase of air control. Write for details and name of Ross representative in your area.



Solenoid-Pilot Sections Interchangeable on all 16 Ross-In-Line Bodies.

ROSS OPERATING VALVE CO.

120 E. Golden Gate Avenue, Dept. 167 • Detroit 3, Michigan

ROSS

THE BRIDLE FOR AIR HORSEPOWER

"PLASTICS are *Right* if they're *Molded* by *Northern*"

This is no idle slogan, or catch-phrase headline. It stands for a reputation honestly earned. A reputation gained through 39 years of molding experience which has given *Northern* designing, engineering and molding personnel a knowledge of *what* compounds to use, *how* and *when* to use them, and the best way to mold *each* one.

The *Lenk Manufacturing Company* capitalized on this highly diversified experience by choosing *Northern* to mold the gun-grip of this unique soldering iron. Phenolic plastic was used. Northern stands ready to prove to you — "Plastics are Right if they're Molded by Northern".

Northern INDUSTRIAL CHEMICAL CO.

39 Years of Plastic Molding Experience

11 ELKINS STREET, SO. BOSTON, MASS. SO. 8-4240

BRANCH OFFICES

441 Lexington Ave. New York, N. Y. Tel. Vanderbilt 6-1684

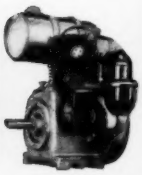
P.O. Box 476 Rochester 2, N. Y. Tel. Charlotte 3270

P.O. Box 5604 Phila. 29, Pa. Tel. Victor 8679

When You Specify

WISCONSIN Air-Cooled ENGINES

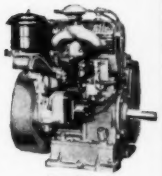
You Get...



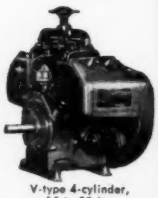
Single Cylinder, 2 to 9 hp.

- Heavy-Duty, long term service . . .
- Weather-proof, automatic cooling . . .
- Foolproof lubrication . . .
- Quick, sure-fire starting in any climate, at any season . . .
- Full load power delivery on a continuous service basis if that's what the job calls for . . .
- Light weight and extreme compactness . . .
- Broad-range power adaptability . . .
- Top economy and operating efficiency . . .
- Ready availability of parts and service if and when needed . . .
- Popular and enthusiastic recognition and endorsement in all fields of engine power service . . .
- Your choice of power to fit the machine and the job in 4-cycle single cylinder, 2-cylinder and 4-cylinder engines, in a power range from 2 to 30 hp.

Let us supply you with full details, including engineering data applying to your specific power problems.



Two Cylinder, 7 to 13 hp.



V-type 4-cylinder, 15 to 30 hp.

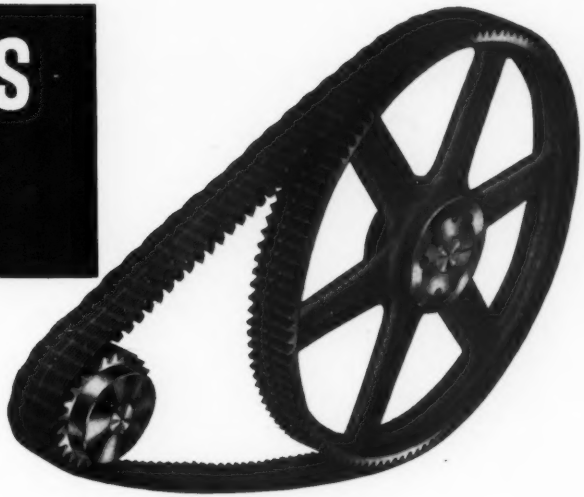
WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 14 WISCONSIN

If You Don't See the Clutch You Want — Ask ROCKFORD
SINGLE OR DOUBLE-PLATE
OVER-CENTER
ROCKFORD
CLUTCHES
The clutch shown above—used in farm tractor LIVE POWER TAKE-OFFS — enables the harvesting unit to be controlled independently of tractor propulsion. It is used in other ways and in other industries. And it is but one of many other types and sizes of ROCKFORD CLUTCHES that have been designed and built to meet specific needs. If you have a power control or power transmission problem, our engineers can help you solve it. Write for our latest bulletin which shows typical ROCKFORD CLUTCHES and POWER TAKE-OFF installations with diagrams of unique applications, capacity tables and specifications.
ROCKFORD CLUTCH DIVISION
BORG-WARNER
209 Catherine Street, Rockford, Illinois

ENDLESS STORY



Morse Silent Chain Drives

THE STORY of Morse Silent Chain Drives is an endless one of efficiency, low cost and positive power transmission.

Perhaps the most effective known means of transmitting power between shafts, Morse Silent Chain is quiet, smooth, and dependable. Considered by engineers as flexible gearing, it has been used to transmit 5000 h.p. in a single drive; speeds have sometimes exceeded 8000 FPM. At high velocities, Morse Silent Chain Drives utilize centrifugal force to distribute driving effort over a greater number of teeth, reducing impact, wear, and noise.

Part of the story of the operating economy and long life of Morse Silent Chain Drives is found in the famous frictionless rocker joint. Employing essentially a simple rocking-chair action, Morse Silent Chain contact is confined to rolling instead of sliding action. Less heat is developed, enabling the drive to transmit heavy loads at high speeds without overheating.

Simple to connect or disconnect, Morse Silent Chains can be installed or removed without dismantling machines on which they are used. Chain length is easily and quickly adjusted for any center distance, and speed ratio changes can be readily accomplished. The initial cost of Morse Silent Chain Drives is surprisingly low, and their high efficiency and frictionless joint design assures the lowest operating cost per hour and low maintenance outlay.

Why not check the Morse Silent Chain story more completely? Write for catalog C71-48. Morse Chain Company, Dept. 288, Detroit 8, Michigan.

★ ★ ★

Morse Roller Chain Drives • A low-cost, positive, efficient, flexible drive for use under rigorous operating conditions. Morse Standard Roller Chain is applicable to a wide range of installations and is available in all American Standard pitches and widths.

Morflex Couplings

Roller Chain Couplings

Silent Chain Drives

MORSE

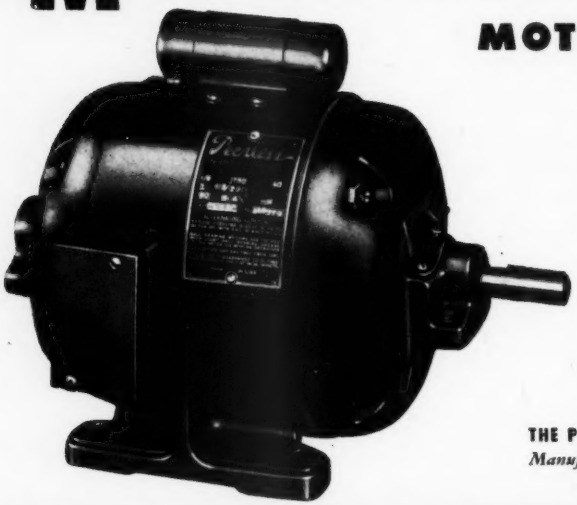
MECHANICAL POWER TRANSMISSION PRODUCTS

A PRODUCT OF B-W BORG-WARNER

Morflex Radial Couplings

MORSE CHAIN COMPANY • DETROIT 8, MICHIGAN

MAKE PEERLESS ELECTRIC *your* MOTOR DEPARTMENT



● When you bring your motor problems to Peerless Electric, you add a motor department to your plant facilities. Peerless is small enough to give individual engineering attention to your motor requirements—large enough to manufacture the motors you need in any quantity.

We can give you the same quick action on special motors that you could get in your own plant if you had a motor department —action that will give you promptly the information or samples you may need.

THE PEERLESS ELECTRIC COMPANY • WARREN, OHIO

Manufacturers of Quality Motors for more than 55 years.

Single Phase • Polyphase • Direct Current Motors

ALL *Peerless Motors* ARE "PEERLESS REGISTERED"

SEE WATSON-FLAGG

FOR GEARS —

QUALITY GEARS

WHERE END PERFORMANCE

DEPENDS ON GEARMAKERS' SKILL

MEMBER AGMA

WATSON-FLAGG MACHINE COMPANY, Inc.
Paterson, New Jersey

LEAKY CHECK VALVES?

HOLD UP TO 20,000 psi

with

TWIN SEAL CHECK VALVES

bubble tight • positive seal

- Liquid or gas . . . size ⅛" to 1" NPT
- Minimum pressure drop—½ psi to open
- Vacuum service, special valves, aircraft
- Equal performance with sediment or grit

Write for Data Sheet CV-947

MANSFIELD & GREEN 1051 POWER AVENUE CLEVELAND 14, OHIO

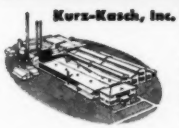
Inside story on the outside of a picture

Television by RCA Victor means entertainment for the millions—but this lower priced, high-quality RCA Victor television set also provides serious food for thought for manufacturers of many other products.
The bezel framing the 10" kinescope, RCA Victor stylists said, should be metal. "Nope," said Engineering, "metal bezels that big have a tendency to pick up electrical disturbances in some areas. Won't meet RCA Victor standards!" "Nope," said Costs, "a complex metal shape that size runs up cost out of proportion!"
"Well, then—metallic appearance," conceded Styling.
So, on the basis of better properties and lower costs, we're plunger-moulding the bezel of plastics. *Heat-resistant* phenolic. Heat-resistant, because big as it is—thin-sectioned as it is—it withstands 1 hour of 250°F. without distortion while a gold enamel finish is baked in. It's tapped, ready to mount, with a minimum of warp, by only 4 corner bosses — to meet RCA Victor's exacting standards.

Kurz-Kasch

FOR OVER 33 YEARS PLANNERS AND MOULDERS IN PLASTICS

Kurz-Kasch, Inc. • 1427 South Broadway • Dayton 1, Ohio

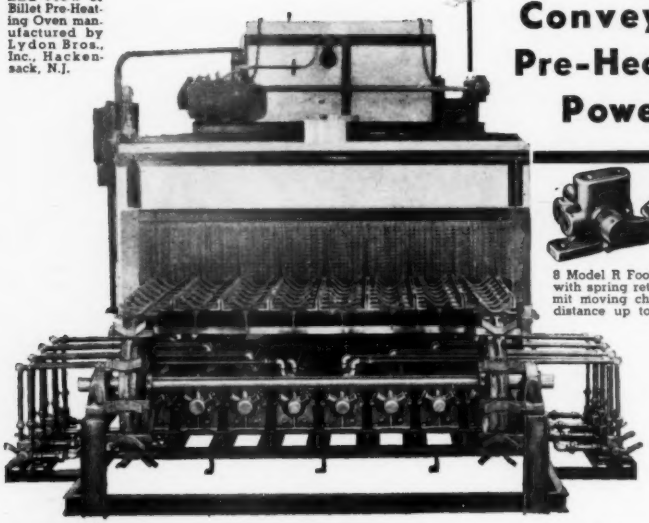


BRANCH SALES OFFICES: New York, *Lexington 2-6677* Chicago, *Harrison 5473* • Detroit, *Randolph 5214* Los Angeles, *Prospect 7503* • Dallas, *Lakeside 1022* St. Louis, *Rosedale 3542* • Toronto, Canada, *Adelaide 1377.*

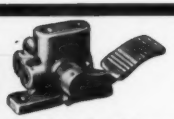
EXPORT OFFICES: 89 Broad Street, New York City, *Bowling Green 9-7751.*

In meeting RCA Victor's specifications on this job, we're justifying again the Kurz-Kasch reputation for superior moulding. Whatever your problems—if they call for imagination in compression, transfer or plunger techniques—we've got the men, the plant, the equipment, and the record of accomplishment. We're ready to tackle the complete job—to handle long runs—to set up and meet early delivery schedules—and we've been doing it since pioneering began in Plastics, May we send an engineer to talk things over?

End view of Billet Pre-Heating Oven manufactured by Lydon Bros., Inc., Hackensack, N.J.



Conveyor Chains on Pre-Heating Ovens are Powered by NOPAK



8 Model R Foot Valves, with spring return, permit moving chains any distance up to 30".

Lydon Bros., Inc., Hackensack, N. J. . . . designers and manufacturers of industrial ovens and dryers . . . employ 8 NOPAK Model A Air Cylinders controlled by 8 NOPAK Model R Foot Valves in this Billet Pre-heating Oven, to actuate the conveyor chains which feed billets into the oven.

Each of the 6" cylinders has a 30" stroke, and is ratchet coupled to one of the conveyor chains. Thus each chain is operated independently, and may be advanced any distance up to 30" with each depression of foot valve pedal. This makes the conveyor system both flexible and selective, an important operating advantage.

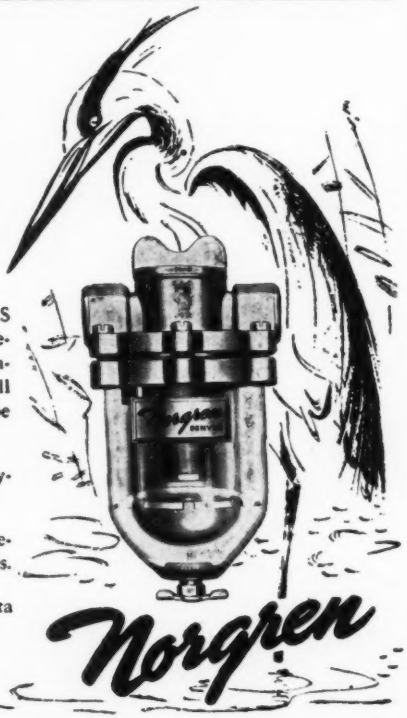
Possibly a similar application of NOPAK Valves and Cylinders can help pull one of your design or production "chestnuts" out of the fire.

GALLAND-HENNING MFG. CO.
2762 S. 31st St., Milwaukee 7, Wis.
Representatives in Principal Cities

NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

NOPAK Model A Air Cylinders like this, with 30" strokes, are used on the Lydon Bros. Oven.

Moisture Proof!



NORGREN **TRANSPARENT BOWL** FILTERS protect air tools and cylinders against damaging, moisture-laden air. *Stop the moisture right before your eyes!* Exclusive TORNADO JET hurls moisture against the outer wall of the bowl where it collects, runs down and can be drained off by opening the waste cock.

BAFFLE PLATE prevents air turbulence from carrying trapped moisture back into the lines.

REINFORCED MONEL SCREEN traps all solids. Designed for positive protection of your air tools and cylinders.

Write for details today: C. A. Norgren Company, 222 Santa Fe Drive, Denver 9, Colorado.

BRING IDEAS ALIVE WITH

MASONITE PRESDWOOD

MADE FROM EXPLODED WOOD

TOO MANY drafting board ideas die a-borning because of limited *material* capabilities.

There's one amazing material—proved for over 20 years—that gives free reign to your creative skill, brings more ideas to life and avoids the limitations of less versatile materials.

It's Masonite Presdwood—the all-wood hardboard that's made from exploded wood. *It combines more valuable characteristics than any other basic material!*

Hard and dense, it has tremendous strength and stability. It resists moisture, scuffs and abrasions. It's grainless, won't shrink, swell, split or splinter. You can bend it into curves, die-stamp, rout, bevel, laminate it, give it almost any finish. It comes in varying thicknesses and densities, smooth on one or two sides—a Presdwood product for every purpose.

Presdwood makes a thousand products better—a thousand better products are made with it. In furniture (a fine cabinet wood), in radios (improves the tonal qualities), in trucks, trains and buses (for strength, durability and handsome appearance), in toys (for ruggedness)—any place where quality construction without high cost is desired. Masonite Corporation, Chicago 2, Ill.

MASONITE CORPORATION
Dept. PE-1, 111 West Washington Street
Chicago 2, Illinois

Please send me, without cost or obligation, a sample of Presdwood and literature about how I can use it profitably as a product design material.

Name _____

Address _____

_____

MASONITE PRESDWOOD *the best wood*

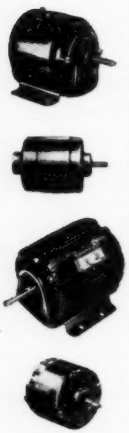
"Masonite" and "Presdwood" are registered trade-marks. "Masonite" signifies that Masonite Corporation is the source of the product.

HERE'S
LOW COST
LOW-RANGE
POWER!

Redmond MICROMOTORS

OVER 100 STANDARD MODELS

A.C. up to 1/15 Horsepower—D.C. up to 1/20 Horsepower



If small motors can make a big difference in the life, performance, or efficiency of your product, best you get acquainted with reliable Redmond Micromotors. They're sturdy little low-range power units... smooth, quiet, dependable in operation... designed, engineered, and built to give you maximum long-life performance at minimum cost. And, with over 100 standard models thoroughly proved in use on countless diversified applications, chances are at Redmond you'll find exactly the Micromotor you want for the job you want it to do. Variations from standard also available to meet special requirements. New Catalog, just off the press, covers both A. C. and D. C. lines plus blowers and speed controllers... want a copy?

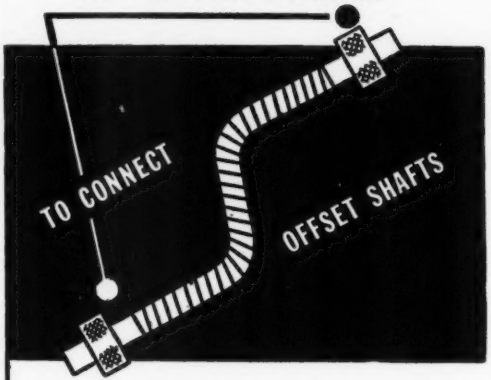
Redmond COMPANY, Inc.
OWOSSO, MICHIGAN

REDMOND

OFFICES IN NEW YORK, CHICAGO, DAYTON, LOS ANGELES, DALLAS

EXPANDED FACILITIES • PROMPT DELIVERIES • SERVICE BEFORE AND BEYOND THE SALE

The Shortest Distance—



Walker-Turner Flexible Shafting

For direct connection between offset shafts, Walker-Turner Flexible Shafting is the shortest distance to trouble-free installation with minimum maintenance.

For a wide range of mechanical drives, acting as a *direct* connection, without the expense and troubles of gears, cams, universals, belts, or linkages, Walker-Turner Flexible Shafting offers all the advantages of more compact design. It is quicker to assemble, simpler to service, easier to maintain.

Flexible shafting, as designed by Walker-Turner, assures power or control connections of lasting strength and full sensitivity... a flexible coupling that takes vibration in stride, that eliminates troubles caused by thermal expansion, or relative movement.

For a comprehensive data book containing design information on Flexible Shafting, Flexible Casing and Tubing, and Flexible Shaft Machines write to

Walker-Turner Division,
Kearney & Trecker Corporation,
Plainfield, New Jersey

Walker-Turner's applied engineering experience has provided the answer to many complex problems of torque and impulse transmission through the use of flexible shafting. Subject your design problems to careful analysis by flexible shaft engineers. *It costs you nothing and may result in considerable savings of time and money.*

Walker-Turner

FLEXIBLE SHAFTING

FLEXIBLE SHAFTING
FLEXIBLE CASING AND TUBING
FLEXIBLE SHAFT MACHINES

NEW . . . HI-10 PHOSPHOR BRONZE SPRING WIRE

- **Increases Tensile Strength 10,000 Pounds per Square Inch**
- **Gives Greater Stability and Prevents Brittleness**
- **Improves Your Springs at NO extra cost**

10 HI-10

New advances in spring design—stronger, longer-lasting springs at *no extra cost*—these are the twin advantages of HI-10 Phosphor Bronze Spring Wire.

10 HI-10

Newest product of Riverside research, HI-10 is warranted to increase tensile strength at least 10,000 pounds per square inch over established standards. It also adds stability and prevents brittleness or any other detrimental effect from aging. Yet, in Grade "A" wire there's no change in standard alloy specifications. HI-10 improves your springs *without* forcing changes in equipment or processing methods—*without* increasing your production costs.

10 HI-10

The special Riverside processing increases the tensile strength of Grade "E" (3% tin) Phosphor Bronze Wire, so that it now possesses the same tensile values presently covered by standard specifications for Grade "A". This lowers your production costs without affecting the quality of your springs. And at the same time, strategic and allocation-controlled tin is conserved.

10 HI-10

Grade "E" HI-10 Phosphor Bronze Wire is highly recommended for formed springs *other than* coil springs. These spring forms are often very difficult to manufacture because of severe bending requirements. Grade "E" HI-10 Phosphor Bronze Wire has excellent ductility and permits twisting and bending to degrees beyond those which can be endured by spring temper Grade "A" Phosphor Bronze Wire. Thus, if you have experienced trouble with the manufacture of such items, Grade "E" HI-10 Phosphor Bronze Wire could be the problem-solver.

10 HI-10

In both Grade "A" and Grade "E", HI-10 Phosphor Bronze Spring Wire is supplied in sizes from .182" diameter down to .0159". Riverside HI-10 is characterized by a somewhat darker, iridescent surface than ordinary phosphor bronze spring wire processed in the conventional way.

We shall be glad to furnish trial orders at published base prices, with prevailing extras for quantity and size differentials. For full details of HI-10 write today.

RIVERSIDE MAKES A FULL RANGE OF STANDARD (AND SOME SPECIAL) NICKEL SILVER AND PHOSPHOR BRONZE ALLOYS

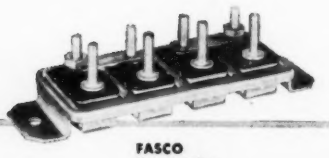
THE RIVERSIDE METAL COMPANY

RIVERSIDE, NEW JERSEY

NEW YORK, CHICAGO, HARTFORD, CLEVELAND
R. J. LEAHY & COMPANY
486 Eighth St., San Francisco, Calif.

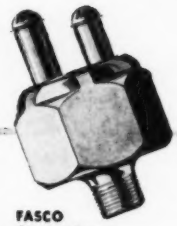
RIVERSIDE

PHOSPHOR BRONZE
NICKEL SILVER
BERYLLIUM COPPER
CUPRO NICKEL



FASCO
Automotive
Circuit Breakers

FASCO
Table Type Fans



FASCO
Automotive
Stop Light Switches

F. A. SMITH MANUFACTURING CO., INC.
ROCHESTER 2, NEW YORK

Announcing

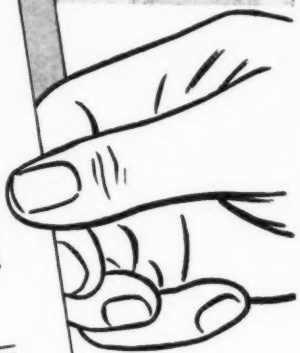
A NEW COMPANY NAME

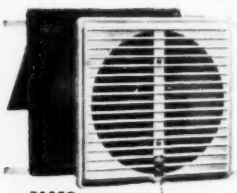
FASCO INDUSTRIES, INC.

Our corporate name now conforms more closely with the trade-mark, "FASCO," used on our products. FASCO represents the *same company* . . . carries on our same long-established reputation for *dependable quality* . . . *superior performance* . . . *right prices*. From now on you can identify our products and company by the names "FASCO" and "FASCO INDUSTRIES, INC."

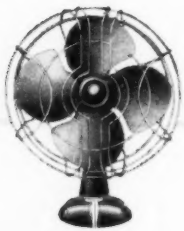
H. P. Toppin, PRESIDENT

H. M. Sylvester, SECRETARY-TREASURER





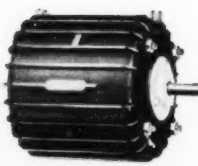
FASCO
Automatic
Kitchen Ventilators



FASCO Desk Fans

FASCO
Blowers

FASCO Fractional H. P. Motors



FASCO Fractional H. P. Motors

EASY-FLO BRAZED

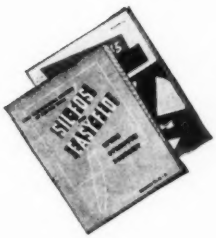
AMERICA'S OUTSTANDING NEW BICYCLE FRAME

— BY Columbia

Chief among the many new developments in Columbia's 1948 line is the silver alloy brazed frame. EASY-FLO is the alloy that does it. The frame above is from the new "FIVE STAR SUPERB" MOTOBIKE model, rated by Westfield, the manufacturer, as "the best bike by Columbia in 71 years". And here's what Westfield says about silver alloy brazing—

"A proven, modern process approved by the best metal engineering practice. This method produces joints of great strength which are absolutely clean of brazing metal, making possible not only a stronger frame but a better looking enamel finish — a better looking bicycle".

To which can be added the widely established fact that low-temperature EASY-FLO silver alloy brazing also makes possible exceptional production rates with big savings in man hours, machine hours and materials.



IT'S EASY TO GET FULL EASY-FLO FACTS

If you want them quick, for a specific job, ask for a field engineer to call. They're also covered in detail in BULLETINS 12-A and 15. Write for copies today.

HANDY & HARMAN

82 FULTON STREET NEW YORK 7, N. Y.

Bridgeport, Conn. • Chicago, Ill. • Los Angeles, Cal. • Providence, R. I. • Toronto, Canada

Agents in Principal Cities

WHEN THIS NEW INDIANA PERMANENT MAGNET

REPLACED THIS OLD ONE

A BETTER SPEEDOMETER WAS BORN

New King-Seeley speedometer

★

Indiana—world's largest exclusive producer of permanent magnets—is the *only* manufacturer furnishing all commercial grades of permanent magnet alloys. Most commonly used are:

CAST:
Alnico I, II, III, IV, V, VI, and XII; Indalloy; Cunico; Cobalt.
SINTERED:
Alnico II, IV, V; Indalloy; Vectolite.
DUCTILE:
Cunico; Cunife 1 and II; Silmanal.
FORMED:
Chrome; Cobalt; Tungsten.

Ask for free Book No. 4-B1—our new permanent magnet engineering manual. A note on your company letterhead will bring a copy to your desk.

40 YEARS OF BETTER PERMANENT MAGNETS

★

Indiana's experience brings Better Designs, Lower Costs

Recently our engineers, working with those of King-Seeley Corp., helped design an entirely new permanent magnet for a greatly improved speedometer. This *Indiana* magnet, made of Cunife, weighs *one third less* than the previous magnet, yet has *30% more energy*. It reduces bearing load by 50%, and is 750% more stable—is *far* more resistant to shock, temperature change, stray magnetic fields. And it *costs less.*

WE MAY HAVE *YOUR* ANSWER, TOO

For four decades, the pace-setting design techniques at *Indiana* have made possible new and better permanent magnets. This "packaged energy" improves performance, adds new functions, *saves money* in countless different products . . . as mechanical force in holding and separating devices . . . for changing electrical energy to mechanical motion and vice versa . . . for changing the apparent characteristics of materials. *Indiana* offers you the experience and know-how of more than 30,000 different applications. Let's get our engineers together on *your* problem. Write *today.*

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILL.

SPECIALISTS IN PERMANENT MAGNETS SINCE 1908
PLANTS: VALPARAISO, INDIANA • CHAUNCEY, N. Y.

FLASH-BUTT WELDED RINGS and BANDS *by* AMERICAN WELDING

Flash-butt welded rings and bands . . . both carbon and alloy . . . prove to be superior. Records show that there is a substantial

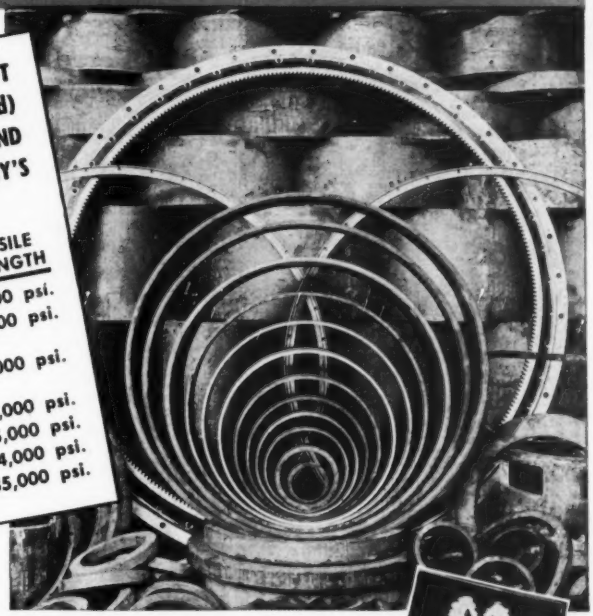
SAVING IN THE PRICE OF RINGS
SAVING IN THE COST OF TOOLING

when rings and bands are produced by the American Welding "Controlled Technique" process of flash-butt welding.

If you use rings, bands, or any other welded product, send your specifications, quantity, and prints for prompt quotation.

REPRESENTATIVE FLASH-BUTT WELD TEST RESULTS (as welded) FROM AMERICAN WELDING AND MANUFACTURING COMPANY'S RESEARCH FILES.

MATERIAL	TENSILE STRENGTH
Armco Ingot Iron	47,000 psi.
AISI-C-1025	71,000 psi.
Stainless, Type No. 410	76,000 psi.
Stainless, Type No. 347	91,000 psi.
AISI-8630	115,000 psi.
Inconel-X	124,000 psi.
N-155	135,000 psi.



***Send* for 16 page illustrated booklet**

THE AMERICAN WELDING AND MANUFACTURING COMPANY

140 DIETZ ROAD • WARREN, OHIO

SYNCHRON
TRADE MARK

TIMING MOTORS AND TIME MACHINES

Timing Motors and Time Machines That Never Need Oiling!

Motor is equipped with oil storage reservoir and patented oil feed to bearings.

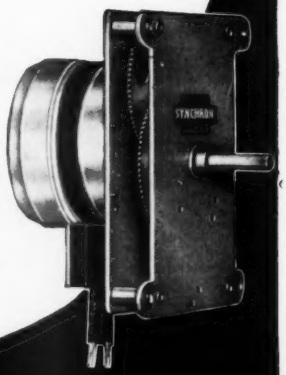
Double Bearings Assure Smooth Operation—

Rotor shaft, reduction train, and output shaft — all have double bearings to reduce vibration and promote quiet operation.

Brass Gears Operate Against Steel Pinions For Long Life!

There is no compromise for quality in the construction of SYNCHRON Timing Motors and Time Machines. Millions of these timers are in operation today in nearly every conceivable type of timing job. There's a new SYNCHRON Catalog now available which tells all the facts. Write for it! And if you have any special timing problems, feel free to call on us for helpful suggestions.

(1-49)



HANSEN MANUFACTURING CO., INC.

Established 1907 - a Pioneer in Synchronous Motors

PRINCETON 5, INDIANA

BRASS and BRONZE DIE CASTINGS and PERMANENT MOULD CASTINGS

Can Cut Your Component Costs

The quality, uniformity and dimensional accuracy found in Brass and Bronze Die Castings and Aluminum Bronze Permanent Mould Castings, make it possible to effect large savings by minimizing finishing operations in the manufacture of your parts. Reduction of set up time, the amount of stock to be removed and machining operations all contribute to cut costs. Then, too, there are instances where entire operations such as hobbing are eliminated. Polishing costs are substantially reduced due to smoothness of surface and elimination of sand holes. The constant dimensional accuracy and quality of these castings also make it possible to standardize production rates, eliminate rejects and in many cases cut assembly time.

Consult your nearby Pressco representative or write for further information. Pressco representatives are in all principal cities.

* Mfd. for CLEVELAND TRENCHER CO.

OTHER PRESSCO USERS

Fairbanks, Morse & Co.	Food Machinery Corporation
The Goss Printing Press Co.	The National Acme Company
Thompson Products, Inc.	Delta-Star Electric Co.
The Elwell-Parker Electric Co.	The Heil Company

PRESSCO

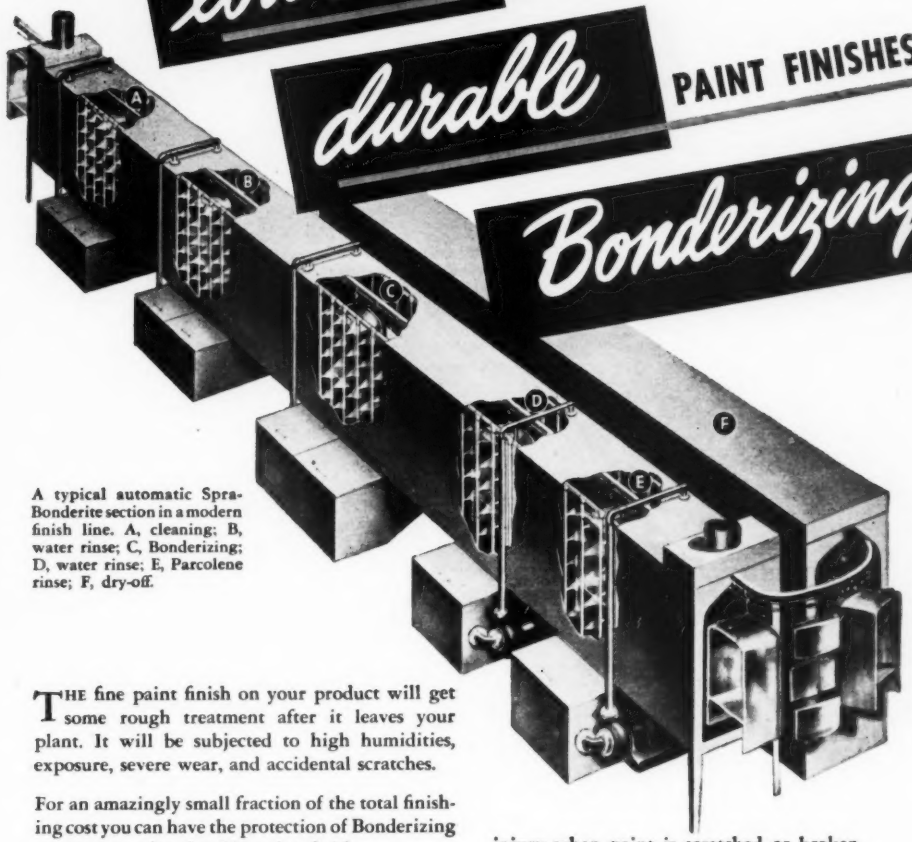
Largest Exclusive Manufacturers of Brass and Bronze Die Castings And Aluminum Bronze Permanent Mould Castings

CASTING & MFG. CORPORATION

CHESTERTON, INDIANA

Head Sales Office: 10 S. LaSalle St., Chicago 3, Illinois

low cost ASSURANCE OF durable PAINT FINISHES— Bonderizing



A typical automatic Spra-Bonderite section in a modern finish line. A, cleaning; B, water rinse; C, Bonderizing; D, water rinse; E, Parcolene rinse; F, dry-off.

THE fine paint finish on your product will get some rough treatment after it leaves your plant. It will be subjected to high humidities, exposure, severe wear, and accidental scratches.

For an amazingly small fraction of the total finishing cost you can have the protection of Bonderizing —assurance of a durable paint finish.

Bonderizing—quick, simple, and easy to control and apply—does these things to protect and preserve fine paint finishes:

It provides a secure anchor to hold paint. No chipping or peeling.

It retards corrosion effectively.

It checks the spread of rust at the site of the injury when paint is scratched or broken.

If your product has a paint finish, protect it and your customer's satisfaction by Bonderizing before you paint.

Full information is yours on request. A letter will bring you details on Bonderizing and what it can do for your product.

Bonderite, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

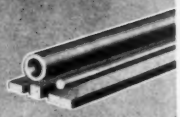
PARKER

PARKER RUST PROOF COMPANY
2179 East Milwaukee Ave.
Detroit 11, Michigan

BONDERIZING Holds Paint to Metal . . . PARKERIZING Inhibits Rust . . . PARCO LUBRIZING Retards Wear on Friction Surfaces

Talide
(TUNGSTEN CARBIDE)
Cutting Tools

TALIDE METAL MEETS EVERY REQUIREMENT



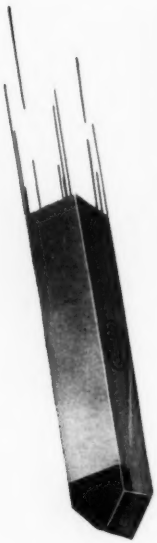
SOLID BAR STOCK

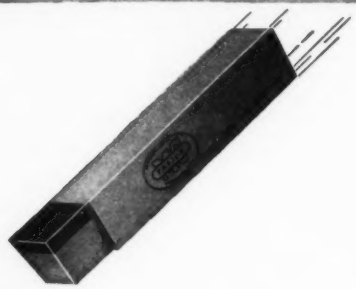
DRAWING DIES

CENTERLESS BLADES

DRILL JIG BUSHINGS

ROLLING MILL WORK ROLLS





2 to 3 TIMES FASTER!

Call our service engineers for assistance on tooling problems

Faster cutting than other tools, Talide Tools and Tips wear much longer and require only infrequent redressings. Same long-run advantages whether you machine steel, cast iron, non-ferrous metal or non-metallic materials.

The quality of Talide Tools never varies. Made from the hardest man-made metal, each Talide Tool and Tip has the same metallurgical consistency.

For lower costs, try Talide Tools and Tips . . . plastic-dipped for protection in shipment or storage. Available in 24 hours or less from warehouses in Newark, Youngstown, Detroit and Chicago.

Send for engineering-style catalog 48-T "Standard Talide Tools and Tips"

SINTERED CARBIDES
MC TALIDE
HOT PRESSED CARBIDES

METAL CARBIDES CORPORATION
YOUNGSTOWN 5, OHIO *Pioneers in Tungsten Carbide Metallurgy*
CUTTING TOOLS . DRAWING DIES . WEAR RESISTANT PARTS

the MODERN WAY . . . to operate

Air Cylinders • Presses

New! Electric

DIRECTAIR

HANNIFIN Air Control Valve!

SEE IT! TRY IT! You'll be amazed at the difference it makes when you use this new Hannifin push button operated air control valve. Without effort, a quick, full power stroke every time! No throttling possible; no short-stroking. Use it to boost production.

10 WATT SOLENOIDS — No pounding . . . no noise . . . no relays needed. Solenoids continuously rated; only momentary contact required. Speeds of 180 cycles per minute, or more!

PILOT TYPE — Remarkably simple! An exclusive Hannifin development. Thoroughly tested. Air pressure does the work with a double-acting piston that operates stainless steel reciprocating disc. No packing or seals to maintain.

NO PACKING TROUBLES — Metal-to-metal lapped valve seat. Long life; little or no maintenance. Remarkably compact. Strikingly styled.

TO MEET YOUR REQUIREMENTS — Type I: Fingertip control of advance and return cylinder strokes through two push buttons. Type II: Single push button control; equivalent to spring return valve action. 3-way or 4-way types. Ideal for remote control . . . building into equipment. Sizes ⅜", ½", and ¾". For any pressure from 25 to 150 p.s.i. WRITE FOR DESCRIPTIVE LITERATURE.

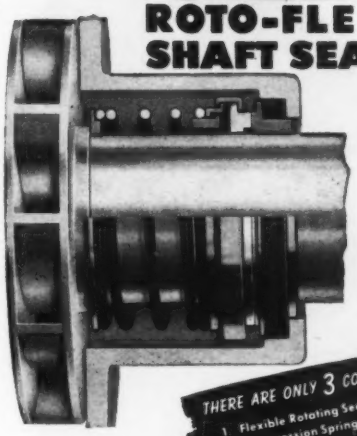
HANNIFIN CORPORATION

Nationwide Sales and Service

1101 So. Kilbourn Avenue Chicago 24, Illinois

ADVANCED DESIGN in SHAFT SEALING

GITS ROTO-FLEX SHAFT SEAL



ADVANCED DESIGN . . . Key to the development of Gits Bros. new ROTO-FLEX SHAFT SEAL. And back of this development lies the detailed research and experience gained by Gits Engineers over many years of designing and manufacturing high speed shaft seals.

The advanced design features of the Gits Roto-Flex Shaft Seal include:

1. No loose parts—permanently assembled Seal Nose.
2. Positive built-in flexibility.
3. Torque washer that relieves diaphragm strain.
4. Balanced design—Minimum spring pressure.
5. Machine-lapped seal surfaces.
6. Easy installation due to extreme construction simplicity.

AVAILABLE SINGLE OR DOUBLE. Where liquid must be added as coolant or lubricant, Gits Roto-Flex is also available in double unit.

The need for the Gits Roto-Flex Shaft Seal is unlimited and UNTIL NOW not fully answered. For proper recommendations on your seal problem, send a dimensioned drawing, showing where the seal is to be applied, for immediate and careful attention by Gits Bros. Engineers. Also include such operating data as:

1. Shaft R.P.M. and direction.
2. Liquid or gas being sealed.
3. Temperature range.
4. Pressure range.

and any special details related to design or assembly. On any shaft sealing problem—as on any lubricating problem—it will pay you to consult with Gits Bros. . . . "Friction-Fighting Headquarters" for over 40 years.

WRITE TODAY for new literature which graphically describes the new Gits Roto-Flex Shaft Seal. Engineering data and many helpful suggestions included. It's Free!

GITS BROS. MFG. CO.

1838 South Kilbourn Avenue, Chicago 23, Illinois

Exclusive Manufacturers of Lubricating Devices for over 40 Years

EXPECT THIS ACCURACY
in the Sleeve Bearings you buy

BEARINGS by Johnson Bronze are precise in every dimension. They are easy to install and they operate efficiently from the start. Achieving this accuracy, consistently, is no accident. Long experience in producing all types of Sleeve Bearings has taught the *correct* speeds, feeds and cuts . . . the proper method of boring . . . the right angle for the chamfer . . . plus the many other fine points that mean the difference between top quality and mediocrity.

Users throughout the nation depend upon Johnson Bronze for such quality. It saves them on assembly costs and improves the serviceability of the finished equipment. Don't be satisfied with less! Since the original cost of Johnson Sleeve Bearings is low, there is no premium charged for this workmanship. Phone the Johnson Branch in your vicinity . . . or write direct for further information.

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS
BRANCHES IN 20 INDUSTRIAL CENTERS

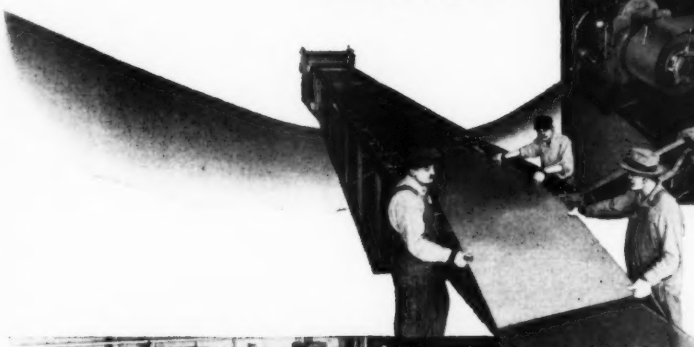
JOHNSON BRONZE CO. 508 S. Mill St., New Castle, Pa.

If You Use SHEET STEEL...

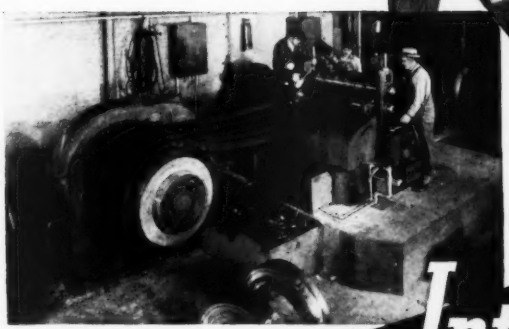
Let International quote on decoiling, flattening, cutting, and pickling. Also on coil-slitting. International's mill-type equipment handles these services at low cost, and assures dependable supplies even though mill facilities are crowded.

Hundreds of manufacturers look to International for steel service to assure a steady flow of incoming materials. Perhaps similar service can be arranged for you ... it will pay to inquire.

Coils up to 9 gauge (.150) can be handled by International's Flying Shear



Sheets from the Flying Shear are smooth, uniform, accurate to size



One of International's three coil-slitters that handle coils up to 60 inches wide

STEEL SERVICE INTERNATIONAL

International

ROLLING MILL PRODUCTS CORPORATION

5033 S. KEDZIE AVE., CHICAGO 32, ILL. Phone HE 4-5200

DIFFERENTIALS

SPUR • HELICAL • HERRINGBONE • SPIRAL BEVEL • STRAIGHT BEVEL • HYPOID • ZEROL • WORMS and WORM GEARS • SPLINED SHAFTS • DIFFERENTIALS

FAIRFIELD is a specialist in producing differentials for all kinds of vehicles. By using Fairfield service, manufacturers get these important benefits:

A BETTER PRODUCT. Finest production facilities, advanced engineering practice, and a highly trained organization of skilled craftsmen stand back of the Fairfield reputation for producing fine gears and differentials!

MASS PRODUCTION ECONOMY. Thanks to large volume of work handled in the Fairfield factory.

A DEPENDABLE SOURCE OF SUPPLY. Serving hundreds of large and small users of gears and differentials. Get acquainted with Fairfield's facilities. Your inquiry will receive prompt attention.

FAIRFIELD Manufacturing Co.
313 So. Earl Avenue
Lafayette, Indiana

for FINE GEARS

SMALL PUMPS CORRECTLY ENGINEERED FOR YOUR NEEDS

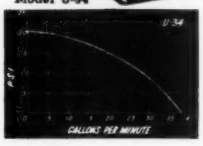
Eastern has designed and built pumps to meet manufacturers' specific needs for many years. Some of these needs have been complex, where the design of a completely new pump was necessary to solve a pumping problem never before encountered. Others were run-of the-mill, where one of Eastern's standard pumps from a line of over 600 different modifications was recommended with the knowledge that it would do the job required of it. Only a company with mechanical, electrical and chemical engineers on its staff could know the correct solution to so many and varied pumping problems. Eastern has such a diversified engineering staff. Thus your pumping problems, especially where small size and light weight combined with high performance and economy of operation are factors, are assured of quick solution. Special pumps when designed and approved, can be put into production when a reasonable quantity is involved.

Illustrated here is a new Eastern Centrifugal Pump. Write for NEW catalog showing many other Eastern Pumps.

VOLUTE CENTRIFUGAL PUMP

Model U-34 illustrated, is designed for handling moderate volumes at relatively high heads, utilizing a minimum of space. It may be used for continuous duty operation. It is an excellent transfer pump. Close-coupled with open impeller mounted directly on motor shaft extension without use of an internal pump bearing. Available with mechanical rotary seal only. Standard models available in Monel Metal, Stainless Steel, Cast Iron, and rough or finished Bronze. Quotations on other alloys on request. Power: Heavy duty General Electric ball bearing motor in various frame enclosures and for almost all current requirements either 1/3 H.P. or ½ H.P. as the application demands. Weight: 36 lbs. Size: 12¼" x 6½" x 6½". Pump performance shown on chart illustrated here.

Model U-34



EASTERN INDUSTRIES, INC.
101 ELM STREET NEW HAVEN, CONN.

Tempilstiks®

the amazing Crayons that tell temperatures

A simple method of controlling temperatures in:

- WELDING
- FLAME-CUTTING
- TEMPERING
- FORGING
- CASTING
- MOLDING
- DRAWING
- STRAIGHTENING
- HEAT-TREATING IN GENERAL

Also available in pellet and liquid form

It's this simple: Select the Tempilstik® for the working temperature you want. Mark your workpiece with it. When the Tempilstik® mark melts, the specified temperature has been reached.

$2 each gives up to 2000 readings

Available in these temperatures (° F)			
125	275	500	1100
138	288	550	1150
150	300	600	1200
163	313	650	1250
175	325	700	1300
188	338	750	1350
200	350	800	1400
213	363	850	1450
225	375	900	1500
238	388	950	1550
250	400	1000	1600
263	450	1050	

FREE —*Tempil® "Basic Guide to Ferrous Metallurgy"* — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

Tempil® corp.
132 WEST 22nd STREET
New York 11, N. Y.

We invite inquiries from reputable distributors interested in handling Tempil® Products.

If You Need A Low Pressure Low Cost Pumping Unit . . .

Complete with:

- ✓ **Pump**
- ✓ **Relief Valve**
- ✓ **Strainer**

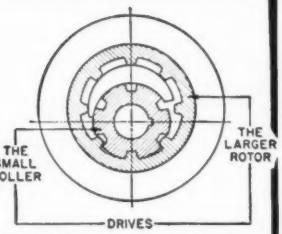
Yes, here's the combination pump you've been looking for. Time-tested, efficient and quiet, it's complete with releif valve and strainer and, like all Sundstrand Pumps, it embodies the ROTA-ROLL principle and pumping members. So, if you need or use pumps of this capacity, be sure to investigate this low cost complete pumping unit.

Available in 5 Sizes: From 6 G.P.H. To 35 G.P.H.

This pump has an adjustable relief valve for settings up to 300 PSI. The five sizes range from 6 G.P.H. to 35 G.P.H. These figures are based on a motor speed of 1725 RPM and 100 PSI.

GET THIS **FREE** BOOK

Rota-Roll Principle Offers 6 Advantages



1. ROTA-ROLL PRINCIPLE of pumping members promotes quiet operation, longer life because (see above) smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.
2. QUIET OPERATION because ROTA-ROLL pumping members and efficient inlet port design reduces cavitation at the inlet port.
3. SMOOTH UNIFORM FLOW AT ALL PRESSURES because rotating roller and rotor are self-emptying, eliminating turbulence, and other interference with smooth uniform flow of oil.
4. SMALL AND COMPACT (see illustration) will lend itself to and improve your product appearance.
5. HIGH OVERALL EFFICIENCY at maximum continuous duty pressure.
6. *LOW COST—Manufacturers list price f.o.b. Rockford, Illinois, for 35 G.P.H. unit $16.90. Priecs for smaller capacity units slightly less.

SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS, U.S.A.

SUNDSTRAND HYDRAULIC DIVISION

2560 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

Who said it costs more

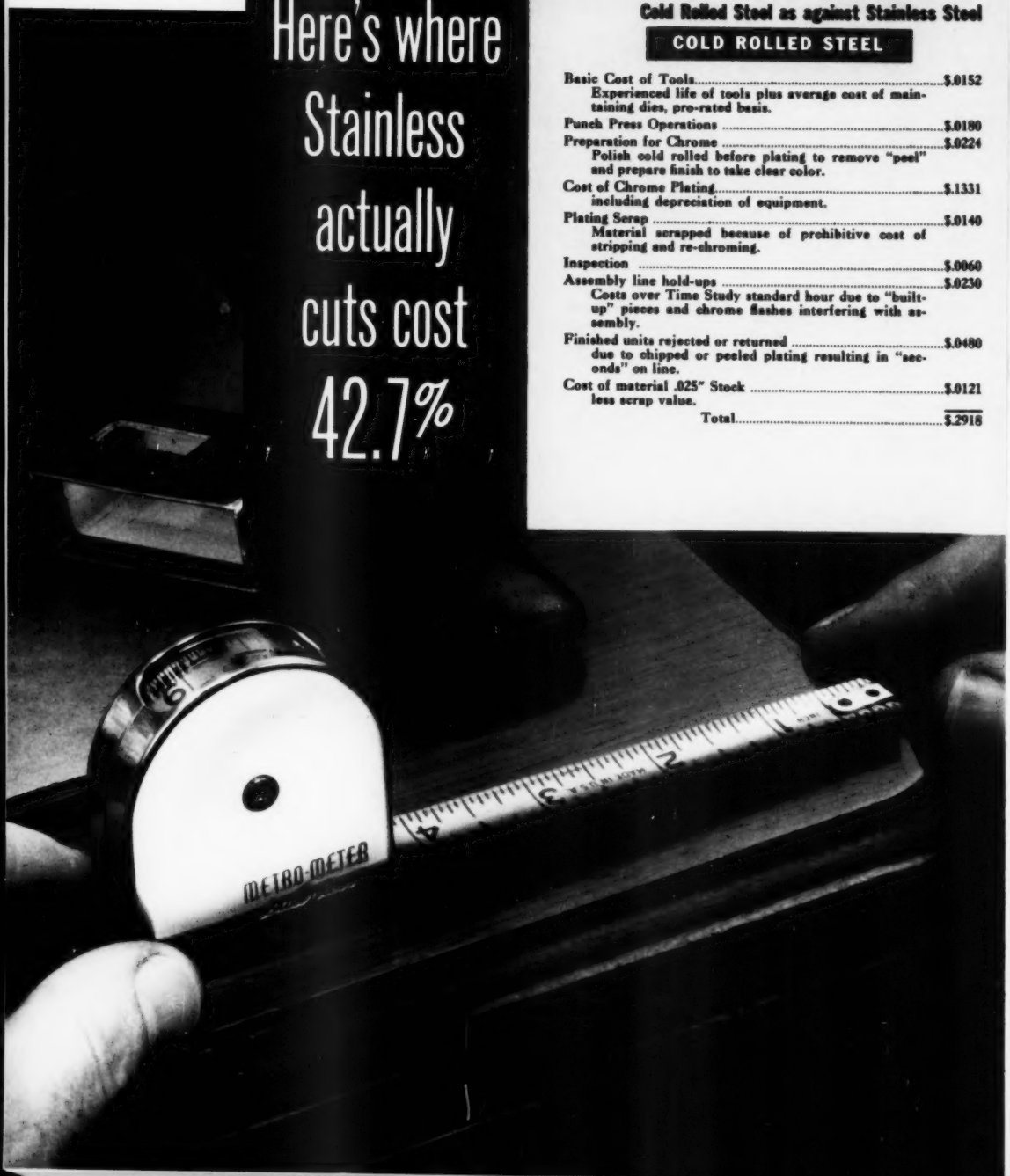
Here's where Stainless actually cuts cost 42.7%

COMPARISON AND

Cold Rolled Steel as against Stainless Steel

COLD ROLLED STEEL

Basic Cost of Tools Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0152
Punch Press Operations	$.0180
Preparation for Chrome Polish cold rolled before plating to remove "peel" and prepare finish to take clear color.	$.0224
Cost of Chrome Plating including depreciation of equipment.	$.1331
Plating Scrap Material scrapped because of prohibitive cost of stripping and re-chroming.	$.0140
Inspection	$.0060
Assembly line hold-ups Costs over Time Study standard hour due to "built-up" pieces and chrome flashes interfering with assembly.	$.0230
Finished units rejected or returned due to chipped or peeled plating resulting in "seconds" on line.	$.0480
Cost of material .025" Stock less scrap value.	$.0121
Total	$.2918



to use Stainless Steel?

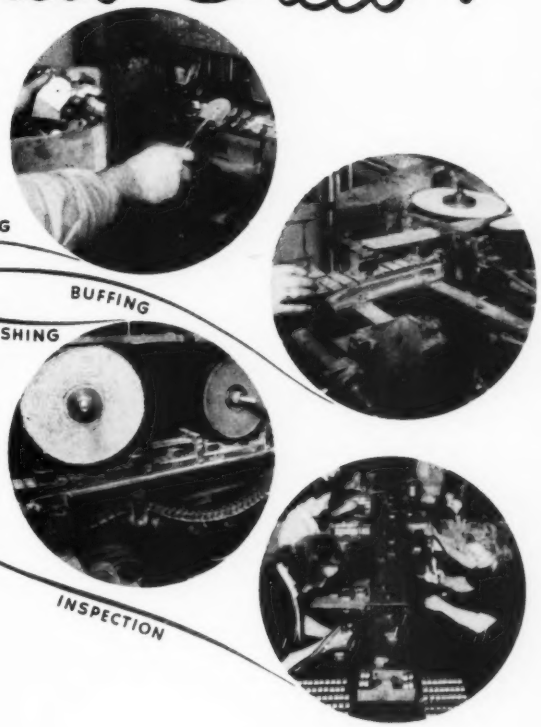
ANALYSIS OF COSTS
as experienced by Dart Mfg. Co., Mason, Mich.

STAINLESS STEEL

Basic Cost of Tools ..... Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0334
Punch Press Operations	$.0180
Polish and Buff ..... including depreciation of equipment and re-running of faulty buffing.	$.0512
Inspection	$.0060
Cost of Material .020" Stock ..... less scrap value.	$.0584
Total	$.1670

Cold Rolled Total Costs . . . . . $.2918
Stainless Total Costs 1670
Actual Experienced Savings . . . . . $.1248 per case

Percentage Reduction in Cost 42.7%



THE "Metro-Meter" is a little device you'll soon be seeing a lot more of. It's a dial-reading steel rule with built-in scribe that men just naturally "take to" because it's practical, obviously useful, and, encased in Stainless Steel, is permanently good looking.

It's the case we want to talk to you about. Originally it was made of cold rolled carbon steel, chrome plated. The steel, itself, was inexpensive. But by the time it was prepared for plating, and plated—after the costs for rejections and returns due to over-plating, under-plating, chipping and peeling were added —each case cost a little over 29 cents.

By using lustrous satin-finish Stainless Steel in place of cold rolled carbon steel, however, all plating costs as well as rejections and returns were eliminated. Even though the initial cost of the Stainless Steel used was about five times that of the carbon steel formerly used, the final *finished* cost in Stainless was exactly 16.7 cents per case—a saving of almost 12½ cents each, which means a 42.7% reduction in cost.

What is more, with the magic word "Stainless" now stamped on the case, an almost irresistible plus has been added. Sales for the "Metro-Meter" which formerly had been good, immediately became considerably better. Thus, Stainless has done here what it has done for many other products – improved appearance, increased durability and reduced sales resistance. And in this instance, it has actually reduced costs as well. In short, a product made of Stainless Steel does *not* necessarily cost more—it only looks as though it did.

. . .

We would be glad to have the opportunity to show you where U·S·S Stainless Steel can be applied to improve YOUR product – to increase its desirability – and, more often than you may expect, to reduce its cost as well.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

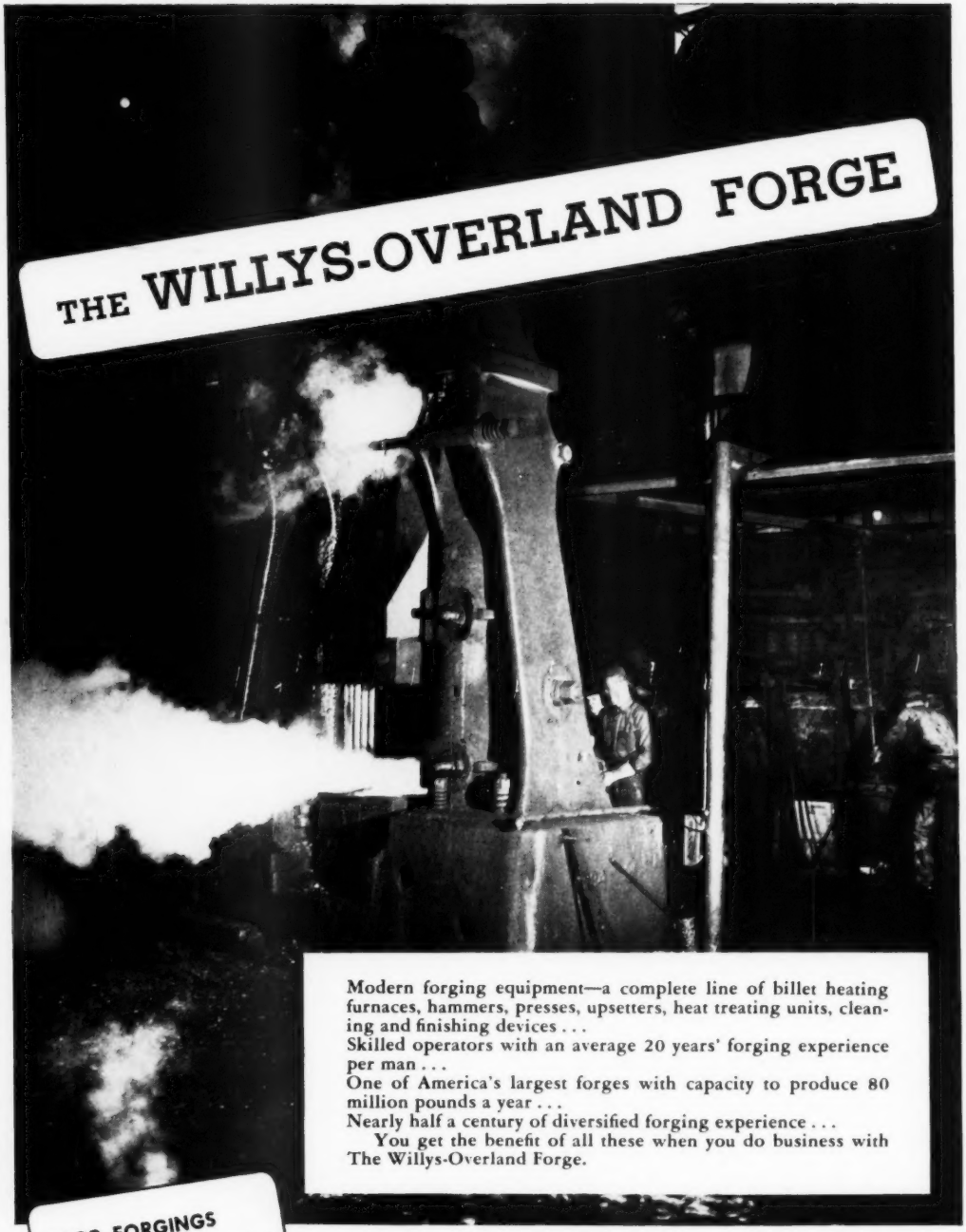
SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

United States Steel Corporation Subsidiaries
Room 2061 Carnegie Building, Pittsburgh 30, Pa.

☐ Please send me the new book, "An Introduction to U·S·S Stainless Steel."
☐ Please have a Stainless representative call on me.

Name.....
Position.....
Company.....
Address.....
City..... Zone.... State.....

UNITED STATES STEEL



Modern forging equipment—a complete line of billet heating furnaces, hammers, presses, upsetters, heat treating units, cleaning and finishing devices . . .
Skilled operators with an average 20 years' forging experience per man . . .
One of America's largest forges with capacity to produce 80 million pounds a year . . .
Nearly half a century of diversified forging experience . . .
You get the benefit of all these when you do business with The Willys-Overland Forge.

DROP FORGINGS
HOT PRESS FORGINGS
UPSET FORGINGS

For complete information, write, wire or telephone

THE WILLYS-OVERLAND FORGE

WILLYS-OVERLAND MOTORS, INC., TOLEDO 1, OHIO

Leach Silo Unloaders, manufactured by the Leach Company of Oshkosh, Wisconsin are a boon to farmers in eliminating an unpleasant chore and conserving ensilage. But packing the 1200 pound, oddly shaped units in such a way that they could be handled and installed conveniently presented a difficult problem. Some method for shipping the machine as a group of sub-assemblies that would pass through small silo doors was essential.

Wirebounds solved the problem. Wirebound engineers "tailored" eleven different boxes and crates to package and protect the various parts of the unloader for safe, convenient shipping and handling. At the receiving end, re-assembly was easier because contents could be seen and identified through the sides of the Wirebounds for unpacking in proper sequence.

Light weight Wirebounds meant real shipping economy for Leach too. Less than seven man-minutes were required for packaging any one of the unloader sub-units and packed crates could be stacked 10 high to conserve valuable floor space!

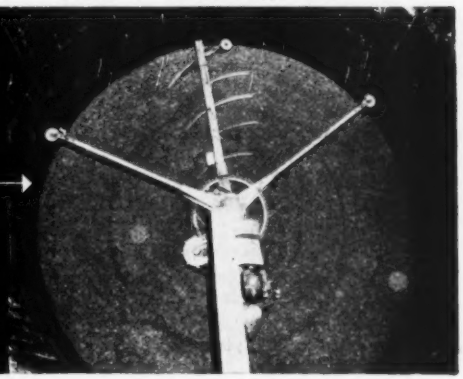
Wirebounds can provide an efficient, economical solution to your shipping problems. Mail the coupon below!

161 pound motor for the Leach Silo Unloader is mounted on a crate base which is engaged by the bottom cleats of the Wirebound.

The door-like fourth side is folded shut and the wires are twisted closed with an electric toggle twister.

another "ODD SHAPE" shipping problem solved by

WIREBOUNDS!



The unusual shipping problem encountered by the Leach Company is readily apparent in the above view of the assembled Silo Unloader.

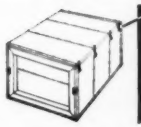
MAIL THIS COUPON TODAY

WIREBOUND BOX MFG. ASS'N.
Room 1820, Borland Building, Chicago, Illinois

☐ SEND COMPLETE LITERATURE ☐ SEND A SALES ENGINEER

NAME POSITION
FIRM NAME
ADDRESS
CITY ZONE STATE
PRODUCT

SIXTY WIREBOUND PLANTS THROUGHOUT THE UNITED STATES

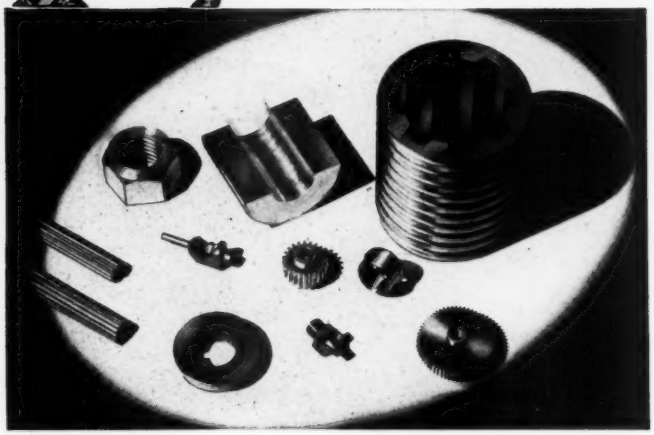


Wirebound
BOXES & CRATES

Unpacking the 11 Wirebounds at the erection site is no problem since the twisted wire closures need only be cut to open.

ONLY Elephant Brand

OFFERS A
COMPLETE RANGE
OF
PHOSPHOR BRONZE
RODS
for EVERY need



Nowhere else have you a choice of such a wide range of alloys, sizes, finishes, machining properties, and resistance to wear and corrosion. Phosphor Bronze Corporation offers a practically *unlimited* choice for any job—whether it calls for peak strength and hardness, highest ductility and toughness, or for best machinability.

COMPLETE RANGE OF ANALYSES, TEMPERS, FINISHES

(1) Choose from *7 non-leaded wrought alloys in many* tempers and 4 different finishes—with tin content from 1% to 10%.

(2) Choose from *5 leaded wrought alloys* for up to 95% relative machinability —choice of tempers and finishes with lead content up to 5%.

(3) Choose from *13 standard chill-cast and turned* alloys—with tin content from 5% to 18½%; lead from 0% to 10%.

WIDEST SIZE RANGE

(1) Wrought alloys from .010" to 4¼" diameter in lengths of 6 to 12 feet.

(2) Chill-cast and turned rods from ½" to 6" diameter.

NOTE: Chill-cast and turned rods are 3 to 6 feet long as compared with 12 to 13 inches usually available. A real saving in set up time and run-outs.

As specialists in Phosphor Bronze, ELEPHANT BRAND blankets the field—for standard or special products. This is your assurance of highest quality and widest selection. Specify ELEPHANT BRAND—truly "the first name in Phosphor Bronze".

The Rod Section of the ELEPHANT BRAND Technical Data Book gives detailed information on the complete rod line. Sheet, wire, rope, and castings are also covered in this fileworthy addition to your reference library.

Elephant Brand
First name in PHOSPHOR BRONZE

THE PHOSPHOR BRONZE CORPORATION
Dept. C — 2200 Washington Avenue, Phila. 46, Pa.

IF IT'S
here...

IT'S news...

IT'S WORTH STOPPING TO SEE!

Maybe Industry doesn't maintain show windows on Fifth Avenue or State Street or Wilshire Boulevard like America's great department stores. But your industry has a mighty effective show window... *and this is it*... this magazine. In these advertising pages alert manufacturers show their wares. Here you will find up-to-the-minute news about products and services designed to help you do your job better, quicker, and cheaper.
To be well-informed about the latest developments in *your* business, *your* industry... and to stay well-informed... *read all the ads too.*

McGRAW-HILL
PUBLICATIONS

Spongex takes weariness out of work

For men at machines as well as at desks, for the housewife as well as for women in industry or the professions, *Spongex** sponge rubber reduces shock, vibration, noise and other discomforts . . . takes weariness out of work.

All the cushioning, sound deadening, sealing, insulating properties of rubber have been multiplied in *Spongex* and precisely engineered to a specific job. Whether a simple seat cushion or the life-critical gasket of an iron lung, a bassinet pad for a newborn baby or the window sealing in a stratosphere-flying plane. Everywhere and, seemingly, in almost every product . . . for refrigerator doors, shoe innersoles, typewriter pads, motor mountings . . . *Spongex* is helping product designers make living easier, quieter, more abundant for everyone.

Spongex does a better job because it's made by a company that for 25 years has concentrated exclusively on making rubber do a better job of cushioning, insulating, sealing. You can see the difference, feel the difference, prove the difference such experience makes. You can have generous samples of *Spongex* to experiment with and test for resiliency, cell structure, tensile strength and resistance to temperature extremes, moisture, acids, corrosive vapors, abrasion and aging. Write today, naming your product and problem. Sponge Rubber Products Co., Derby 123 Place, Shelton, Conn. Sales offices in principal industrial centers.

*Trade Mark Reg. U.S. Pat. Off.

SRP

SPONGE RUBBER PRODUCTS CO.

SPONGEX • CELL-TITE • TEXFOAM • TEXLITE • TEXLOCK

The bushings on this lead-in insulator are bathed in oil—yet they stand up almost indefinitely without deteriorating. That's because they are made of General Electric silicone rubber, a material with amazing properties of heat-, cold-, and chemical-resistance.

These G-E silicone rubber bushings make a leakproof lead-in connection on a sealed washing machine motor which runs in oil. G-E silicone rubber also has excellent dielectric characteristics, and its low compression set assures a leakproof seal.

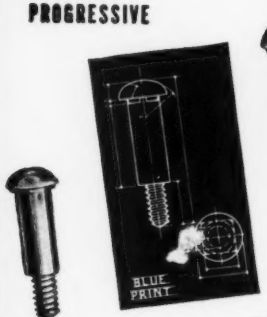
G-E silicone rubber stays resilient throughout an extreme range of temperatures (—55 F to 520 F). It doesn't soften and stick to hot metal surfaces. So it is ideal as a gasketing material for oven doors, high-compression engines, valves, and chemical equipment. Available in extruded, molded, and fabricated forms. Write for latest technical information. *Section 6-I, Chemical Department, General Electric Company, Pittsfield, Massachusetts.*

SILICONE RUBBER

CD49-G1

GENERAL ELECTRIC

ANOTHER SPECIAL BY PROGRESSIVE



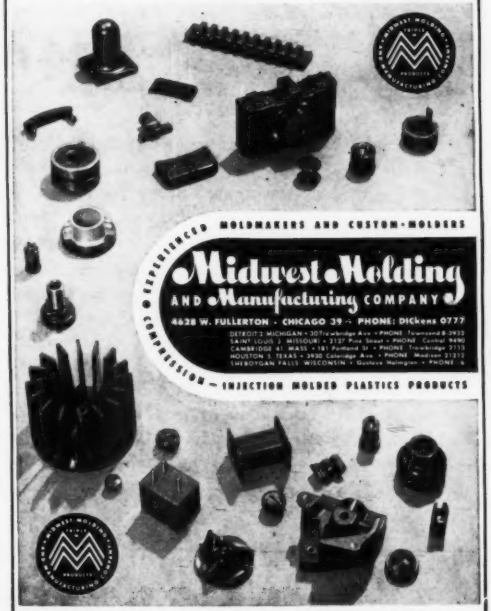
CATALOG SHOWS DOZENS MORE

Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 19.

The PROGRESSIVE MFG. CO.

48 NORWOOD ST., TORRINGTON, CONN.

CUSTOMOLDED PLASTICS



EXPERIENCED MOLDMAKERS AND CUSTOM-MOLDERS

Midwest Molding AND Manufacturing COMPANY

4628 W. FULLERTON • CHICAGO 39 • PHONE: Dickens 0777

DETROIT 2, MICHIGAN • 301 Fisher Bldg. Ave. • PHONE Townsend 8-3933
SAINT LOUIS 3, MISSOURI • 2137 Pine Street • PHONE Central 9490
CAMBRIDGE 41, MASS. • 181 Portland St. • PHONE Trowbridge 7155
HOUSTON 5, TEXAS • 3930 Calvacade Ave. • PHONE Madison 21272
NEENAH-MENASHA, WISCONSIN • Business Managers • PHONE 6

COMPRESSION — INJECTION MOLDED PLASTICS PRODUCTS

FOR ALL APPLICATIONS

Announcing A New LOW COST Ball Bearing for Your

LINEAR MOTIONS

THE COMMERCIAL GRADE SERIES B

BALL BUSHING

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A Ball Bushing.

The low-cost Commercial Grade Series B bearing is now added to the Ball Bushing line and offered to original equipment manufacturers. This ball bearing has been developed for support of linear motions in competitively priced, volume produced products where super precision is not essential. Alert designers can now make tremendous improvements in their products by using Ball Bushings on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Competition is returning. Up-to-date engineering can be *important to you!*

- LOW FRICTION
- ELIMINATE BINDING AND CHATTER
- SOLVES SLIDING LUBRICATION PROBLEMS
- LASTING ALIGNMENT
- LOW MAINTENANCE
- LONG LIFE

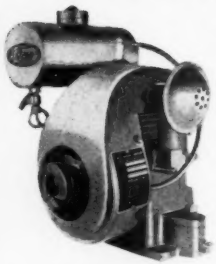
NOW AVAILABLE for ¼", ½", ¾" and 1" shaft diameters. Additional sizes to follow. Write for new literature covering both the Series A and Series B Ball Bushings and the name of our representative in your city. No obligation.

THOMSON INDUSTRIES, INC.

Dept. F *MANHASSET, NEW YORK*

PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS – A MAJOR IMPROVEMENT AT A MINOR COST

LAUSON POWER is DEPENDABLE Power!



- Dependable Lauson engines add extra sales appeal to your products — build repeat business through customer satisfaction.
- Sizes from ¾ to 5 H. P. 4-Cycle, Air-Cooled.
- Light weight — instant starting — economical operation.
- Machined mounting pad on crank case for direct mounting of pumps, generators, etc.

NATION-WIDE LAUSON SERVICE AVAILABLE EVERYWHERE

Dept. PE, The LAUSON Company, New Holstein, Wis.

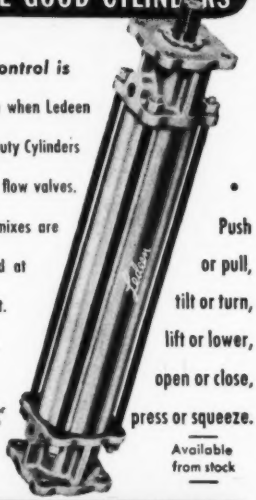
LAUSON

In Canada: Hart-Emerson Ltd. Winnipeg, Canada

ENGINE BUILDERS FOR OVER 50 YEARS!

Ledeen CYLINDERS ARE GOOD CYLINDERS

Mix control is accurate when Ledeen Heavy Duty Cylinders operate flow valves. Better mixes are provided at less cost.



Push or pull, tilt or turn, lift or lower, open or close, press or squeeze.

Available from stock

Send for Bulletin 453

ENGINEERING PRODUCTS CO.

LEDEEN MANUFACTURING DIVISION

1602 SAN PEDRO • LOS ANGELES 15, CAL.

Quantity PRODUCTION of GREY IRON CASTINGS

ONE OF THE NATION'S LARGEST AND MOST MODERN PRODUCTION FOUNDRIES

ESTABLISHED 1866

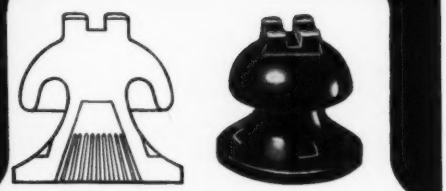
THE WHELAND COMPANY

FOUNDRY DIVISION

MAIN OFFICE AND MANUFACTURING PLANTS

CHATTANOOGA 2, TENNESSEE

HOW LONG CAN A SKIRT BE?



Insulators with "skirts" present the ceramic engineer with some of his most difficult problems. Specifications on this one required a "skirt" depth of full 3/4". Meeting that specification in production quantities called for some very ingenious mold design. The result...a typical example of the experienced engineering and craftsmanship Universal applies to the solution of problems in porcelain insulation. If you have a design or production problem in porcelain insulation, Universal engineers will be glad to help you solve it.

THE UNIVERSAL CLAY PRODUCTS CO.

1545 EAST FIRST STREET SANDUSKY, OHIO

TRADE MARK

Exceptional Opportunities for DESIGN ENGINEERS

Right now—in the engineering department of the Boeing Airplane Company in Seattle, Washington—are openings for graduate (or the equivalent) aeronautical, mechanical, electrical, and civil engineers. For servo-mechanism designers and analysts there are unusual opportunities.

At Boeing your engineering skill and imagination will be applied to the most advanced military and commercial types of aircraft. The work involves all phases of aircraft design, from the detailing of small parts to the layout of major components, stress analysis, weight control, vibration and flutter analysis, research, development, and all associated engineering work required for completion of the design of the final product.

There's a future for you at Boeing where the current backlog of business totals more than $400,000,000. Outstanding engineering research facilities are available to you. Your associates will be the men who have contributed to Boeing's reputation for leadership in aviation research, design and engineering.

To all these advantages that Boeing offers you, add the fact that living is pleasant in the Pacific Northwest. No extremes of heat and cold. A wide variety of recreation is available the year round—fresh and salt water sailing and fishing, skiing, golf, and mountain climbing.

Similar openings are available in the Boeing-Wichita, Kansas plant. Inquiries indicating a preference for Wichita assignment will be referred to the Wichita Division.

For an illustrated brochure, "As the Twig is Bent," on Boeing engineering, and additional information about the opportunities discussed here, write "Personnel Office, Engineering Division, Boeing Airplane Company, 7754 E. Marginal Way, Seattle 14, Washington."

ANSWERING YOUR QUESTIONS

1. What about housing? *Recent new employees have had no difficulty. Our Personnel Unit will give you all possible assistance in finding suitable housing.*
2. What are opportunities for advancement? *Opportunities in all engineering units are virtually unlimited and depend primarily on training, ability and application of the individual.*
3. Does Boeing need men with advanced training? *Definitely yes. Men with advanced training and degrees are very much in demand and command correspondingly higher starting wages.*
4. What are the working hours? *Normally an eight hour day and five day week—8:00 to 4:30 daily.*
5. Is there a formal school or training program? *New engineers are normally placed in a group commensurate with their qualifications. A short training program carried on concurrently with design assignments is given for familiarization with Boeing procedures and practices.*

ADDED ADVANTAGES OF WORKING AT BOEING

1. Two weeks vacation with pay.
2. Ten days sick leave per year—if necessary.
3. Low cost group medical plan.
4. Low cost accident and health insurance.
5. Unusually attractive group life insurance.

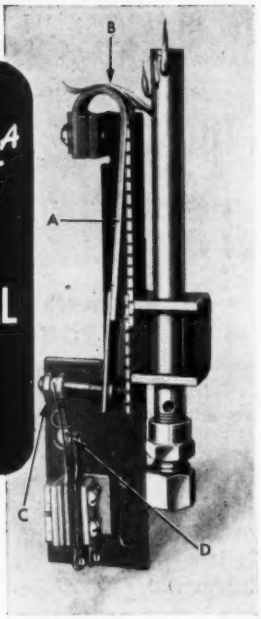
For the Air Force, Boeing is building the B-50 bomber, XB-47 jet bomber and C-97 transport; for the Army, the L-15 liaison plane; and for six major airlines, the twin-deck Boeing Stratocruiser.

BOEING

CHACE BIMETAL . . .

HEART WITHIN A HEART in the

CONTINENTAL SAFETY PILOT



No. 23 — A product of the Continental Instrument Company, Cleveland, Ohio

The Continental Safety Pilot, product of Continental Instrument Company, is a typical use of thermostatic bimetal in which the flame acts directly on the thermal element. Unfailing response of this element is essential for safe burner operation. The pilot is the *heart* of a gas furnace control system—Chace Thermostatic Bimetal is the *heart* of the pilot!

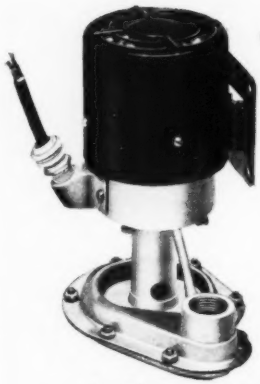
The "U" shaped bimetal element "A" remains as shown as long as heat is maintained by pilot flame at B. Should pressure drop, extinguishing or reducing flame, bimetal cooling moves to position shown by dotted lines, snapping switch C to open contacts D. Control circuit breaks, allowing valve to close in gas line, cutting gas flow to burner. When pilot is relighted, reaction to heat will snap switch, closing circuit and permitting gas valve to open when room thermostat calls for heat.

When designing actuating elements for temperature responsive devices consult W. M. Chace Company. Our engineering department stands ready to serve you.

W. M. CHACE CO.
Manufacturers of Thermostatic Bimetals
1607 BEARD AVE. • DETROIT 9, MICH.

Brady Pumps

FOR COOLANTS, AIR-CONDITIONING, REFRIGERATION



- All-brass construction, rust proof, light weight, low cost. Heavy duty oversize motor, totally enclosed. Ball bearing, one-piece shaft.

Special pumps designed, engineered and manufactured to meet your requirements.

F. E. BRADY PRODUCTS, INC.
18TH AT EBRIGHT • MUNCIE, INDIANA

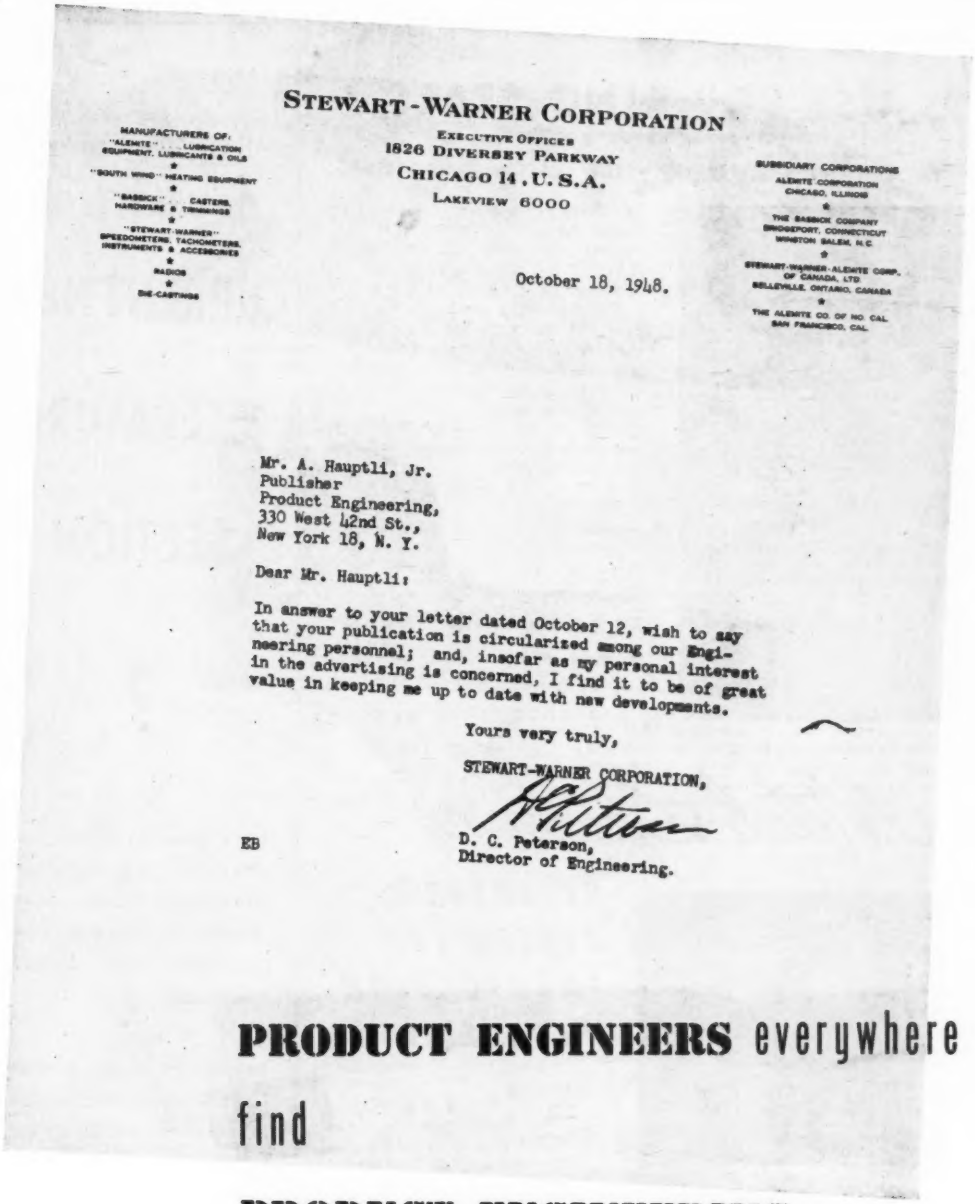
Reprints Available!

EXPERIMENTAL STRESS ANALYSIS SYMPOSIUM

A 16-page insert, featuring histories of applications of experimental stress analysis methods which resulted in design improvements, appeared in the December 1946 issue of *Product Engineering*.

For those who would like copies of this insert for distribution among their technical staffs, a limited supply of reprints is available at 15c each.

PRODUCT ENGINEERING
330 WEST 42ND ST.
NEW YORK 18, N. Y.



STEWART-WARNER CORPORATION

EXECUTIVE OFFICES
1826 DIVERSEY PARKWAY
CHICAGO 14, U. S. A.
LAKEVIEW 6000

MANUFACTURERS OF:
"ALEMITE" LUBRICATION EQUIPMENT, LUBRICANTS & OILS
"SOUTH WIND" HEATING EQUIPMENT
"BASSICK" CASTERS, HARDWARE & TRIMMINGS
"STEWART-WARNER" SPEEDOMETERS, TACHOMETERS, INSTRUMENTS & ACCESSORIES
RADIOS
DIE-CASTINGS

SUBSIDIARY CORPORATIONS
ALEMITE CORPORATION
CHICAGO, ILLINOIS
THE BASSICK COMPANY
BRIDGEPORT, CONNECTICUT
WINSTON SALEM, N.C.
STEWART-WARNER-ALEMITE CORP. OF CANADA, LTD
BELLEVILLE, ONTARIO, CANADA
THE ALEMITE CO. OF NO. CAL.
SAN FRANCISCO, CAL.

October 18, 1948.

Mr. A. Hauptli, Jr.
Publisher
Product Engineering,
330 West 42nd St.,
New York 18, N. Y.

Dear Mr. Hauptli:

In answer to your letter dated October 12, wish to say that your publication is circularized among our Engineering personnel; and, insofar as my personal interest in the advertising is concerned, I find it to be of great value in keeping me up to date with new developments.

Yours very truly,

STEWART-WARNER CORPORATION,

D. C. Peterson,
Director of Engineering.

EB

PRODUCT ENGINEERS everywhere

find

PRODUCT ENGINEERING

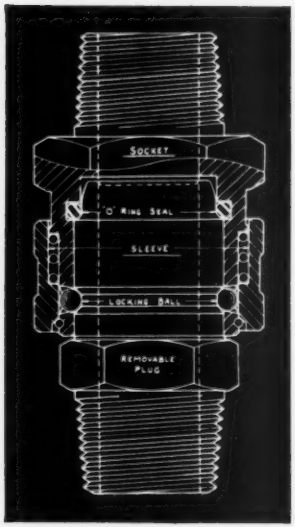
advertisements

of great practical value

USE "O" RING SEALS

(The modern packing method)

for SIMPLICITY • RELIABILITY • LOW COSTS • SPACE SAVINGS



"O" Ring Seals made possible this simple, straight through, quick disconnect coupling by THE HANSEN MANUFACTURING COMPANY of Cleveland, Ohio.

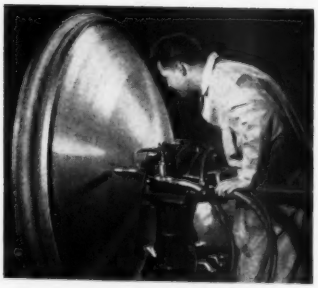
The end of the removable plug is tightly sealed by the "O" Ring when the plug and socket are in the locked position. Yet the plug can be removed and re-connected thousands of times without leakage.

Think of how complicated, bulky and costly this coupling would have been had conventional packings been used.

You, too, may have a problem that can easily be solved by using simple "O" Ring designs. For complete Engineering Data write for our "O" RING HANDBOOK.

PLASTIC and RUBBER
Products, Inc.
Oakridge Drive, Dayton 7, Ohio

Metal Spinning



RE-SOLVES DESIGN and FABRICATION PROBLEMS

IMMEDIATE CAPACITY AVAILABLE

Complete facilities for sheet metal working and spinning of all metals — including stainless steel — are available at Teiner. Blanks ranging in diameter from up to 16 feet to the size of a thimble may be spun to meet tolerances formerly limited to other methods. Designs regularly in production at Teiner include stainless steel shrouds, aluminum reflectors, metal hemispheres, guards, baffles, parabolic shapes, flanged and dished heads. Estimates prepared promptly from your samples or drawings — consult Teiner and save time and money.

ROLAND TEINER COMPANY, INC.
134 Tremont Street · Everett 49, Mass. · EVerett 7-7800
Products Engineered and Manufactured

Have You Checked the Listings in Our CURRENT NEW LITERATURE SECTION ?

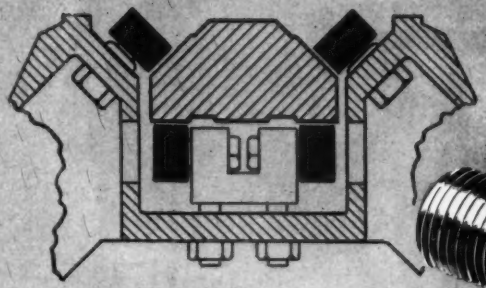
Since resumption of this popular *Product Engineering* feature, almost 2,000 requests for catalogs, booklets and bulletins have been received every month.

Be sure you use this *Product Engineering* reader service to help keep your library up-to-date. The reply cards printed on each CURRENT NEW LITERATURE page are for your convenience in requesting literature which interests you.

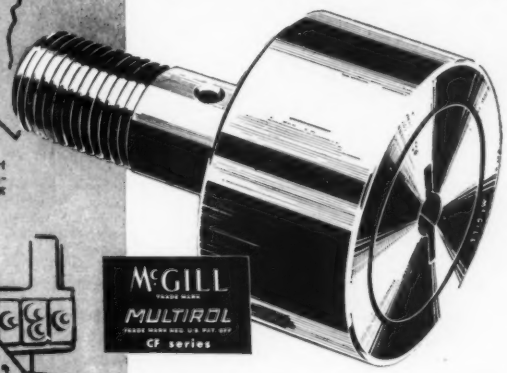
Increase Machine Efficiency *with . . .*

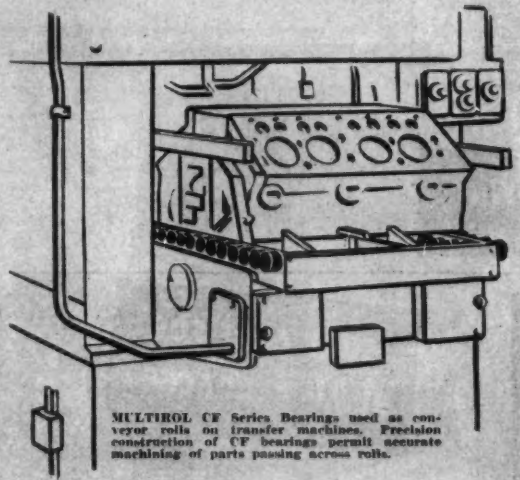
ANTI-FRICTION PERFORMANCE

the *MULTIROL* way

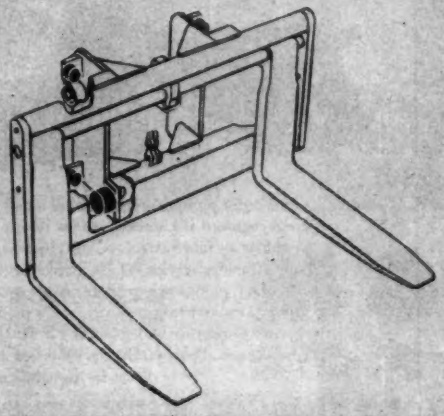


MULTIROL CF Series Bearings as support rollers for oscillating heads and tables on machine tools. Saves costly grinding and scraping of ways.





MULTIROL CF Series Bearings used as conveyor rolls on transfer machines. Precision construction of CF bearings permit accurate machining of parts passing across rolls.



MULTIROL CF Series Bearings as mast and platform guide rollers on lift trucks. Eases lifting and side adjustment of heavier loaded platforms.

When your design goal is the ulumate in anti-friction performance . . . when your specifications include heavier static and shock load capacity . . . then MULTIROL Cam Follower (CF series) bearings are what you've been looking for.

The Cam Follower is a rugged bearing. An extra heavy outer race section stands the repeated shock of cam operation. A full complement of small diameter rollers make up an almost unbroken steel ring which distributes the load evenly over a greater bearing surface. Internal wear and friction are held to the minimum, and power requirements of MULTIROL bearing equipped machines are appreciably lessened. CF bearings are easily lubricated through the stud or face of the bearing and sufficient lubrication is retained for adequate protection of those neglected applications.

MULTIROL Cam Follower bearings are precision built in a range of twenty-two standard roller diameters from 5/8" to 4". This wide variety eliminates the need for special cam follower specifications in most machine design.

For dependable and long lasting anti-friction applications, at lower cost, investigate MULTIROL CF series bearings. Ask our engineers for their recommendations.

Write for Bulletin CF-40A. McGILL Manufacturing Company, Inc., 201 North Lafayette Street, Valparaiso, Indiana.

The "EXTRA SOMETHING" that spells TOP PERFORMANCE

THEY BOTH HAVE IT!

A QUICK EYE, accurate judgment and greater speed give the hockey star the "extra something" that spells top performance.

Many elements, likewise, join forces to produce the "Extra Something" that makes top performance possible in Seletron Selenium Rectifiers.

Among these are correct design — quality of component parts — highest structural strength — precision methods of manufacture — quality control — and final testing, insuring longevity and uniformity.

We receive many unsolicited testimonials praising Seletron Rectifiers for their dependability. Let the experience of these satisfied users guide you in the selection of a rectifying unit.

Seletron Rectifiers are available in a wide range of sizes, from high voltage power stacks to the low ma. types of the "Miniature Family."

Write today for catalog. Address Dept. PS-13

For assured dependable service in all Electronic and Radio applications specify Seletron Miniatures.

CODE NUMBER	5L1	5M1	5P1	5R1	5Q1
Current Rating	75 ma.	100 ma.	150 ma.	200 ma.	250 ma.
Plate Height	1"	1"	1 3/16"	1 1/2"	1"
Plate Width	7/8"	1"	1 3/16"	1 1/4"	1"

RP SELETRON DIVISION
RADIO RECEPTOR CO., Inc.
Since 1922 in Radio and Electronics
251 W. 19th St. • New York 11, N.Y.

Metron

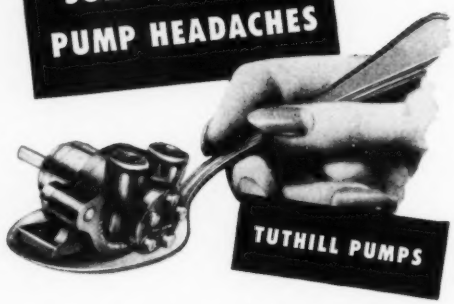
MINIATURE SPEED CHANGERS
★
COMPLETE
COMPACT
ADAPTABLE

- Over 500 different Standard ratios! 10:9 to 3375:1
- SMALL! 1.050" Diameter. Overall lengths: Type 5A, 3-3/16" Type 5B, 4-1/32" Type 5C, 4-13/16"
- Transmit power either way up to 230:1 ratios!
- Concentric ball-bearing input and output shafts.
- Hardened steel spur gears.
- Permanent lubrication.
- Prompt deliveries on production or experimental quantities.

BULLETIN No. 100
Gives complete details—Write for it today to METRON INSTRUMENT COMPANY, 446 Lincoln Street, Denver 9, Colorado.

BUILT BY Metron MAKERS OF INSTRUMENTS FOR PRECISION MEASUREMENT

SURE CURE FOR PUMP HEADACHES



Forget pump worries. Tuthill small pumps are recognized the world over for their dependability in lubrication, coolant, hydraulic and liquid transfer service. These internal-gear type rotary pumps are available in capacities up to 200 g.p.m. and pressures up to 400 p.s.i. Wide choice of porting and mounting arrangements in both packed and mechanically sealed pumps. Write for General Catalog.

TUTHILL PUMP COMPANY
939 East 95th Street, Chicago 19, Illinois

SOCKETS *Extraordinary*

We make them in dozens of styles and sizes. For industrial use — sockets that hold the bulb in tight contact regardless of vibration. Sockets that fit into small spaces for small bulb spotlighting work. Socket adapters that screw into standard sockets and provide bayonet base for smaller bulbs — as for example flash bulbs on cameras, etc. Sockets for electronic devices, electric eye, radio testing equipment, etc. Sockets are our business — in stock or made to order.

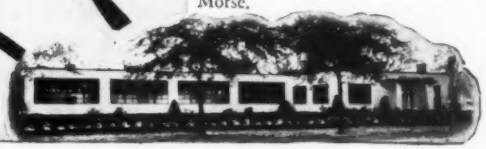
On one of your machines you want a work light built for the job — send us blueprint and specifications and we will build it.

Maybe you want a wire guard to protect bulbs from flying pieces or from other hazards — we have what you want or can make it. Connectors too — for joining extension lines — many types and sizes.

We are specialists in sockets and near cousins thereto.

We will work directly with you on Special Design and Quantity orders. Your Mill Supply House or Electrical Jobber will provide every assistance.

When you think of Sockets think of Morse.



THERE IS A MORSE SOCKET TO MEET EVERY SPECIAL REQUIREMENT.

MORSE SOCKETS

IF YOU HAVE A SOCKET PROBLEM — LET US SOLVE IT.

FRANK W. MORSE COMPANY, 1300 Soldiers Field Road, Boston 35, Mass.

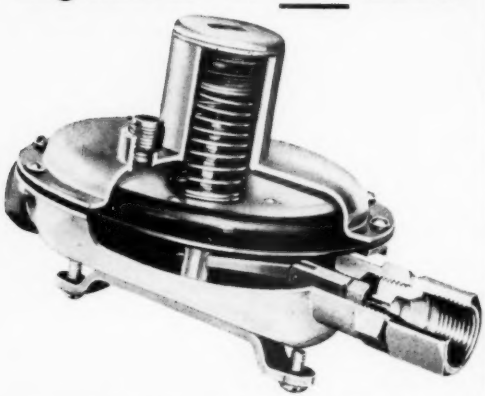
Also manufacturers of PLUG RECEPTACLES • LAMP SOCKET ADAPTERS • SOCKET EXTENSIONS • BAYONET TYPE SOCKETS BRASS CLEATS • WIRE CONNECTORS • SWITCHES • COPPER and BRASS TERMINALS • LAMP GUARDS • CEILING and CLOCK GUARDS

DIAPHRAGMS

by

LINEAR

Engineered for Your Needs



LINEAR, a recognized leader in the field of precision moulded diaphragms, is constantly alert to the ever-changing needs of industry.

The super-sensitive diaphragm shown here is another example of LINEAR Diaphragms built to *your* specifications—*custom made but mass produced* . . . LINEAR Diaphragms that are precision moulded permit easier assembly, lower costs and make positive fluid or gas-tight seals.

LINEAR's reputation has been built on the ability of our engineers to specify materials and design patterns that will produce the most efficient diaphragm for the specific application.

Write for more detailed information. If you have a specific design problem send full information and blueprints to LINEAR.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

CASH-ACME Type A-16 Pressure Reducing Valve

Write for your free copy of our new 1948 Catalog, giving full details about CASH-ACME Products, or ask your mill supply dealer for—

If your equipment requires uniform pressures to operate correctly, don't let it bother you. CASH-ACME manufactures all types of pressure control equipment from ¼" to 2" pipe sizes for water, air, oil, steam, gas and liquid service.

If one of our standard models doesn't do the job, we'll try and develop a special valve for you.

CASH-ACME *Automatic Valves*

A.W. CASH VALVE MANUFACTURING CORPORATION

6662 EAST WABASH AVENUE, DECATUR, ILLINOIS, U. S. A.

Capillary Tubing

ALL KINDS

ALL SHAPES

ROEHR PRODUCTS CO.

131 EAST 19TH STREET

NEW YORK CITY

WILLIAMS

DROP-FORGINGS

ANY SHAPE • ANY MATERIAL • COMPLETE FACILITIES

Write for Free Forging Data Folder . . . Helpful, Informative

J. H. WILLIAMS & CO., "The Drop-Forging People" BUFFALO 7, N.Y.

BUNTING BRONZE BEARING ALLOYS

Bunting Alloy Number			PHYSICAL PROPERTIES								CHEMICAL COMPOSITION									Alloy Number		
Standard Stock	Preferred Alternate	Second Alternate	Order of Anti-Friction Property	Impact Value Charpy Test	Yield Strength Compressive Limit	Ultimate Strength Tensile	Yield Strength Tensile	Elongation Tension	Brinell Hardness 10 mm Ball—500 Kg Load	Rockwell—E Scale Hardness 1/8" Ball—100 Kg Load	Copper Cu	Tin Sn	Lead Pb	Zinc Zn	Iron Fe Max.	Antimony Sb Max.	Nickel Ni Max.	Phosphorus P Max.	Other Elements Max.	SAE Equivalent	Similar Alloys	BUNTING Alloy Number
	158		1	2.9	13,000	20,000	10,000	8%	38	27	69.00 71.00	4.50 5.50	23.50 26.50		.20	.20	.20	.05	.35			158
	125		2	2.7	14,000	22,000	11,000	12%	40	32	73.00 77.00	4.00 5.00	18.00 23.00	1.00 Max.	.20	.20	.25	.05				125
	124		3	5.4	17,000	28,000	14,000	15%	50	52	84.00 86.00	4.50 5.50	8.00 10.00	1.50 Max.	.20	.20	.25	.10		66		124
	135		4	2.4	18,000	28,000	14,000	15%	52	55	75.00 79.00	7.00 9.00	13.00 17.00	1.00 Max.	.20	.20	.25	.05				135
		162	5	2.7	20,000	30,000	15,000	15%	55	59	69.00 73.00	8.50 9.50	17.50 22.50		.20	.20	.25	.05	.25			162
72			6	3.8	20,000	34,000	16,000	18%	58	63	81.00 85.00	6.50 7.50	6.00 8.00	2.00 4.00	.20	.20	.35	.15	.20	660		72
		27	7	2.6	21,000	35,000	17,000	18%	60	65	78.50 81.50	9.00 11.00	9.00 11.00	0.75 Max.	.20	.20	.25	.10		64		27
		147	9	5.6	17,000	35,000	17,000	15%	60	65	85.00 89.00	7.50 8.50	.75 1.50	2.25 4.25	.20	.20		.05 .10	.25	621		147
	96		8	5.8	22,000	40,000	18,000	20%	65	70	86.00 89.00	9.00 11.00	2.00 3.00	1.00 Max.	.20	.20	.25	.10		63		96
		98	10	3.7	22,000	40,000	18,000	20%	65	70	86.00 89.00	9.00 11.00	0.35 Max.	1.00 3.00	.06	.20	.25	.10		62		98
		156	11	1.7	22,000	40,000	18,000	20%	67	72	88.00 90.00	10.00 12.00	0.50 Max.	0.50 Max.				.10 .30		65		156
	164		12	2.7	23,000	40,000	18,000	20%	70	75	85.25 87.75	10.00 12.00	1.00 1.50		.30	.20	.75 1.25	.30 .20	.25	640		164
		143	13	0.8	24,000	40,000	18,000	10%	76	80	84.00 86.00	13.50 14.50	1.50 Max.	0.25 Max.	.20	.20		.10	.25			143

● This is the alloy page from the paper, "Cast Bronze Bearing Alloys". We will send you the complete paper on request.

THE BUNTING BRASS & BRONZE COMPANY, TOLEDO 9, OHIO

BRANCHES IN PRINCIPAL CITIES

WHY IT PAYS TO SPECIFY "S.S.WHITE"

ON ALL FLEXIBLE SHAFT APPLICATIONS . . .

Here are four top reasons why you can count on S.S.White flexible shafts to do a better job on your power drive or remote control flexible shaft applications:

1. SMOOTH, POSITIVE OPERATION— Combining the best in design and construction, S.S.White flexible shafts of either the power drive or the remote control type give smooth, positive performance.

2. LONG LIFE—when properly applied, S.S.White shafts give years of dependable, troublefree service. They're made of special grades of wire to exacting quality standards. And they are engineered to operate with low internal friction.

3. EXACT DUPLICATION — S.S.White's strict adherence to original specifications and careful control over production and materials assures complete uniformity of desired characteristics in each and every foot of shafting supplied.

4. BACKED BY LONG EXPERIENCE — 70 years of leadership in the design and mass production of flexible shafts has given S.S.White the answers to the many details which determine successful flexible shaft performance.

GET FULL DETAILS IN THIS FLEXIBLE SHAFT HANDBOOK

250 pages of facts and data on flexible shaft construction, characteristics and application sent free, if you write for it on your business letterhead and mention your position.

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO. — DEPT. D, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AND ACCESSORIES
MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

One of America's AAAA Industrial Enterprises

Yearly Increasing Value for Readers of

PRODUCT ENGINEERING

Total Editorial Pages

1943—828

1944—858

1945—924

1946—1,112

1947—1,257

Growing Coverage of a Growing Field

* How to raise gears to live and work together

HERE'S A PAIR of twins and a set of "quads" born and raised to live long and work well as a team. They come from a long-lived family of products that has earned a reputation for staying on the job. "Double Diamond" is the name.

No one factor is responsible for this. Rather it is the hard day-to-day job of holding to one set of standards in *all* manufacturing processes. Each individual Double Diamond employee knows that his job is just as important as any other to the performance of the final product. That's our idea of the way to make gears. And if gear performance has a bearing on the performance of your products, on the integrity of your trade mark, we'd like to do business with you.

A letter or phone call will place our engineering department at your service.

DOUBLE DIAMOND
TRADE MARK
GEARS

Made by
Automotive Gear Works, Inc.
RICHMOND, INDIANA

• • • • • FOR AUTOMOTIVE FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS • • • • • •

*Reg. U.S. Pat. Off.

DO YOU KNOW ABOUT THIS BEARING?

BRONZOIL — another Dodge "First"! Designed primarily for the exacting requirements of fan and blower service as well as for general service on small shafts. A *quality* bearing at lowest cost.

Its capillary bronze bushing has a capacity of one-third of its volume in oil. A liberal oil reservoir with close-fitting wick surrounds the bushing, provides complete lubrication.

An absorbent filler holds oil in the reservoir and prevents overlubrication. Self-lubricating bearing surface for the collar is provided by a shoulder on the bronze bushing.

Bronzoil BEARING
TYPE "F"

Fully self aligning. Split pressed steel housing. Remarkably strong and thoroughly dependable, for quality products. Neoprene oil resistant grommets for insulation of sound are available. Write for special bulletin on Dodge Type "F" BRONZOIL bearings.

DODGE MANUFACTURING CORPORATION
Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER

He is your local Dodge Distributor — factory trained — qualified to suggest ways to improve your machine performance, increase production. Look for his name under "Power Transmission Equipment" in your classified phone book.

Copyright, 1948, Dodge Mfg. Corp.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY,
ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS

One of a series of messages to help you increase your understanding of business paper advertising, and its effect on your job

No matter what you make —you're not making it at a profit !

YOU MAY HAVE the finest product of its kind. Your production set-up may be a miracle of efficiency. Perhaps you've even discovered how to cut your cost-per-unit below that of your closest competition. The fact remains —

You're still not *making* anything at a profit. Because actually, of course, there is no such thing.

Goods can only be *sold* at a profit. And selling them profitably requires the same kind of mechanization that keeps your production costs down.

In the *manufacture of a sale*, for example, there are five basic operations —

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

Any good salesman can handle all five. But no salesman should *have* to — not when the first three can be mechanized so economically through the use of advertising.

For good advertising, like the machine on your production line, is a multiplier of individual effort, enabling all of us to produce (and *earn*) far more than we could alone.

And when it goes to work in *business papers* — with their tremendous concentration of hand-picked prospects — advertising becomes the most efficient machine available for manufacturing sales at a profit!

PRODUCT ENGINEERING

is a member of The Associated Business Papers, who have published an interesting folder entitled, "10 ways to measure advertising effectiveness." We'll be glad to send you a copy. And if you'd like reprints of this advertisement (or the entire series) to pass along to others in your organization, just say the word.

Design Ideas to Cut Costs of Wheels, Gear Blanks, Pulleys

THE examples shown are typical of the different ways in which wheels, gear blanks and pulleys are being built with arc welding. These basic designs can be modified to suit your production needs, depending upon the quantity to be made and the kind of fabricating equipment available.

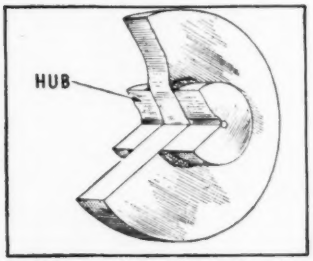


Fig. 1. *Simple gear blank* is made by fillet welding the hub to the web. Parts are flame cut from steel plate.

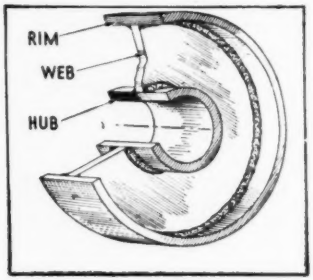


Fig. 2. *Alternate design.* Hub is machined from tubing and rim is rolled from steel strip. Hub and rim are fillet welded to web.

Fig. 6. *Handwheel.* Rim is formed from round bar stock or tubing. Spokes are plain round stock. Steel handwheels will not fracture from impact.

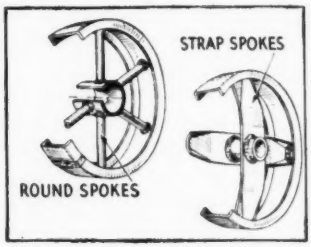


Fig. 3. *Low cost wheel* is made with spokes formed from round bars or steel straps. Spokes are fillet welded inside the channel rim. Hub if required is produced from steel tubing.

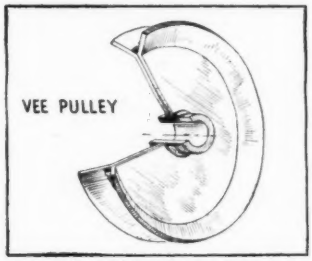


Fig. 4. *Pulley* is fabricated from two steel discs formed to produce a vee-shaped rim.

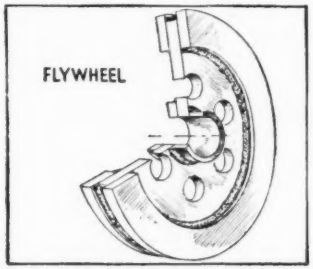
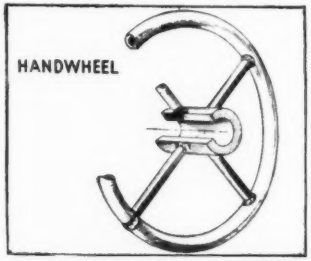
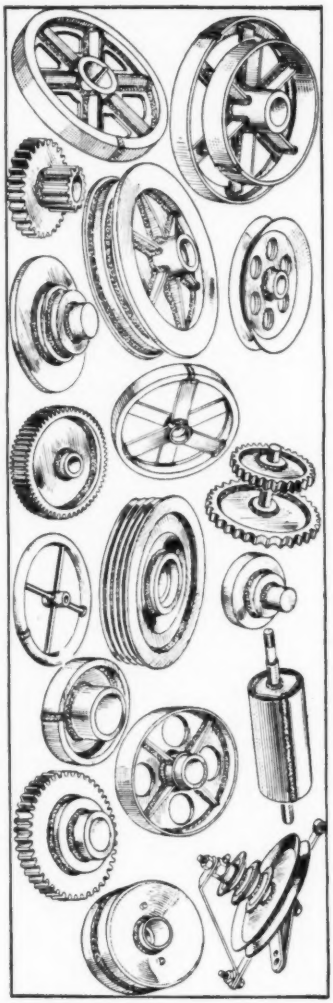


Fig. 5. *Flywheel* is made by welding two steel rims to web by a single groove weld. With welded design, metal is concentrated where it is needed most . . . at the rim.

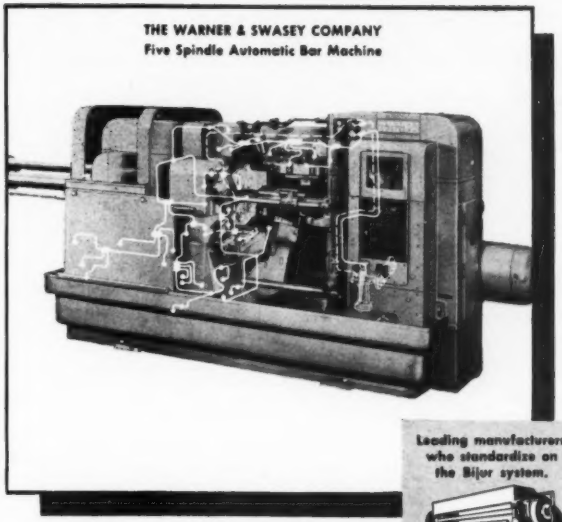




Detailed information on the design of all types of machine parts is contained in the "Procedure Handbook of Arc Welding Design and Practice." Price $1.50 postpaid in the U.S.A.; elsewhere $2.00.

The above is published by **THE LINCOLN ELECTRIC COMPANY** *in the interests of progress.*
Machine Design Studies are available to engineers and designers. Write on your letterhead to The Lincoln Electric Company, Dept. 31, Cleveland 1, Ohio.

Your machines run smoother, longer...



...on bearings oiled by an automatic system of "metered" lubrication

Your machines run smoother, longer and continuously on Bijur-oiled bearings.

Smoother because the correct oil film is constantly maintained by meter-units at the bearings. *Longer* because overall bearing wear is considerably reduced by positive control of oil flow. *Continuously* because a Bijur-equipped machine oils itself while running, eliminating down-time for lubrication.

These factors enable the user to boost production output, cut maintenance costs, and also lengthen the effective life of the machine.

Increased Production Output. A Bijur-lubricated machine oils itself while running, doing away with wasteful down-time for lubrication. Daily maintenance time is thus converted into more time for production.

Decreased Maintenance Costs. A Bijur-lubricated machine assures positive control of oil flow, considerably reducing bearing wear. Longer effective bearing life results in less down-time for repairs and maintenance.

If lubrication is your problem, why not call on the Bijur engineer, or write for "The Travels of Modern Lubrication." This quarterly bulletin shows how leading manufacturers protect performance and maintain production by using Bijur-lubricated machines.

BIJUR

LUBRICATING CORPORATION

LONG ISLAND CITY 1 NEW YORK

884

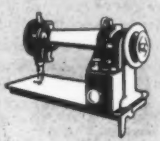
Leading manufacturers who standardize on the Bijur system.

SHEET METAL MACHINERY
Verson "Press Brake"

PACKAGING MACHINERY
Pneumatic Scale "Rotary Top Closing Machine"

FOOD MACHINERY
Baker Perkins "Dough Divider"

PRINTING PRESS
ATF "Chief Offset Press"



TEXTILE MACHINERY
Willcox & Gibbs "Lockstitch Machine"

Like these manufacturers, you too can "be sure with Bijur."

ASK FOR SAMPLES

Pat'd & Pats. Pend.

FLEXLOC ONE-PIECE SELF-LOCKING NUTS

The one-piece, all-metal, resilient "Flexloc" is becoming widely accepted, because it is processed to have an exceptionally uniform torque, and because it is a stop, a lock and a plain nut all in one. All its threads are "live" and load-carrying; "Flexloc" accommodates itself to a wide range of thread tolerances, and can be used over and over again without losing much of its torque . . . is not affected by temperatures commonly met within the industrial field of Mechanical Engineering . . . and being a "stop" nut, it stays locked in any position on a threaded member . . . and last, but not least—it won't shake loose!

The *Thin* "Flexloc" has become very popular because its *tensile* is so high and the space it occupies so small.

Sizes from #6 to 2" in diameter—in "regular" and "thin" types —in NC and NF thread series. Write for *"Flexloc" Catalog.*

OVER 46 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNSYLVANIA, BOX 545

Chicago • Detroit • St. Louis • San Francisco

LAYOUT FLUID

Send for Your FREE Sample

For Machinists, Toolmakers, Diemakers, Model Makers, Template Makers and Layout Men—also for general machine shop and toolroom use on tools, dies, jigs and fixtures and machine surfaces, this Layout Fluid has a considerable advantage over the old copper sulphate method.

With the use of this Layout Fluid, you simply wipe the surface clean and brush it on. It dries instantly.

Send for your *free sample* of this Combination Brush-in-can. Please use your letterhead.

DAYTON ROGERS MFG. CO.

Minneapolis 7, Minnesota

MACHINE-SHOP LOSSES COST MORE THAN CASTINGS

Pictured above is a ten-ton Advance casting for the bed of a broach grinder. If such a casting contained interior defects, the job would have to be welded or scrapped after hours of expensive machine time had been spent on it.

Many shops are searching for predictable castings. This accounts for jobs coming to us from long distances.

Our customers have found that it's economical to pay the freight on Advance castings to save the grief and expense of running into blowholes, cold shuts, cracks, and other obstacles to machining.

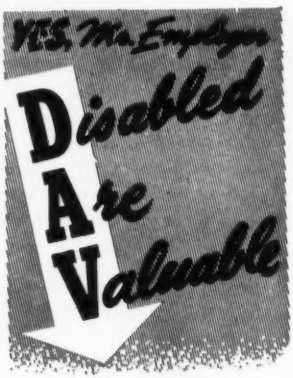
For many years we have specialized on *Strenes Metal* cast dies which require soundness and accuracy of the highest order. We maintain the same standard on gray iron and alloy castings for machining. You are invited to consult with us.

THE ADVANCE FOUNDRY CO.

DAYTON 3, OHIO

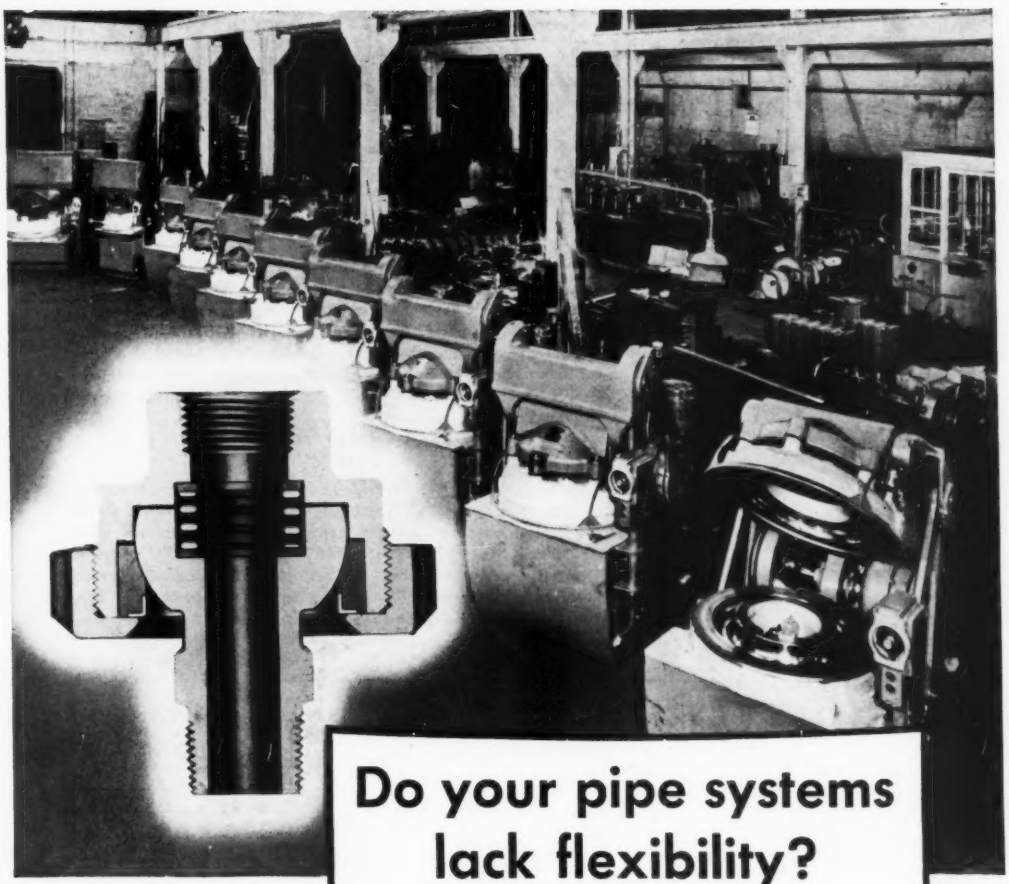
ADVANCE CASTINGS

STRENES METAL • ALLOY GRAY IRON • GRAY IRON



IT'S GOOD BUSINESS TO EMPLOY DISABLED VETERANS

NATIONAL HEADQUARTERS—Cincinnati, Ohio



Do your pipe systems lack flexibility?

Here's an example of how

BARCO CAN PROVIDE IT

Every tire press in this assembly line is equipped with Barco Swivel Joints which provide the piping flexibility required to open and close the press.

For over 30 years Barco Joints have been serving industry and transportation—each year becoming more and more popular. Today, they are used in almost every kind of job requiring *flexible* fluid-conveying systems. By absorbing strain and stress, by compensating for expansion and contraction, Barco Joints have long been practically indispensable. Write for full information to Barco Manufacturing Company, 1827 Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Canada.

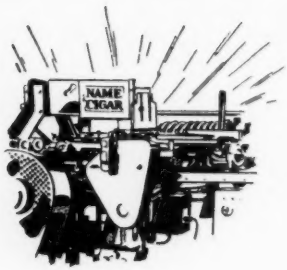
BARCO FLEXIBLE JOINTS

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

"MOVE IN EVERY DIRECTION"

Sealing Profits into packaging equipment



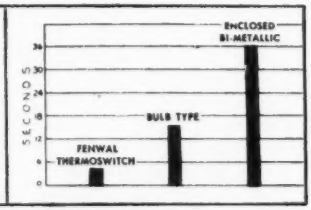
Keeping adhesives at proper sealing temperature is vital in many types of cellophane-packaging machinery. That's why — early in his planning — a prominent manufacturer of this type of equipment turned to Fenwal Thermotechnics for positive heat control. Cartridge type THERMOSWITCH* Controls were the trouble-free, economical answer. Consistently successful in solving all types of temperature control and detection problems, Thermotechnics may prove invaluable in ironing out your own design-difficulties. Let Fenwal aid in your planning.

You Can Choose From
Eleven THERMOSWITCH* Types

Uniform sensitivity, low thermal lag and high resistance to vibration characterize each of the eleven different THERMOSWITCH* Control types. Add rugged, tamper-proof construction and you have the secret of positive, close temperature control from −100 F to 600 F. THERMOSWITCH* Controls may be inserted in closed gas or liquid systems; applied to incubators, ovens, ducts, warming and cooling cabinets, etc.; submerged in liquids or gasses. Your own application may be one of these — or among the new ones constantly being discovered.

Fast Reaction Time

Showing the almost instantaneous response of the Fenwal THERMOSWITCH* Control, compared with two other thermostats. Reaction time is the measured interval required for switch to change 10 F when suddenly subjected to temperatures 20 degrees higher than the ambient temperatures.



Send For Full Information

Write for your copy of the latest Fenwal Bulletin containing complete specifications, test results and application data on THERMOSWITCH* Controls.

Fenwal, Incorporated
15 Pleasant Street, Ashland
Massachusetts

THERMOSWITCH*

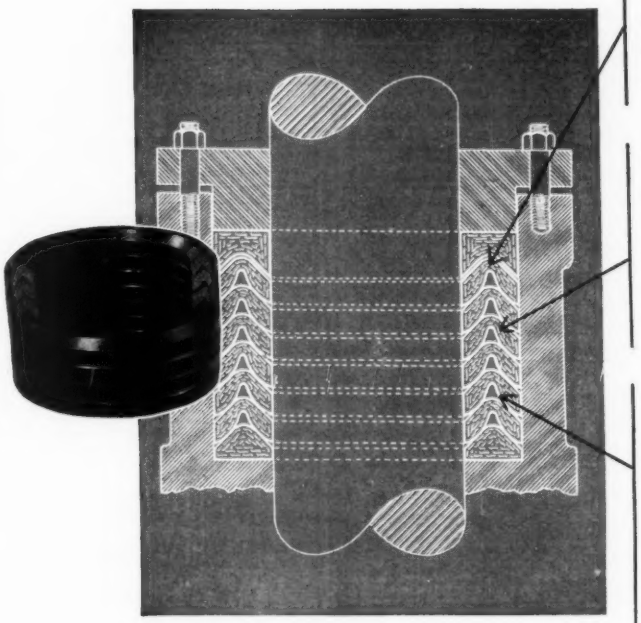
Temperature Controls . . . Over-Heat and Fire Detectors

SENSITIVE . . . *but only to heat*

*Reg. U. S. Pat. Off.

Specify

. . . R/M VEE-FLEX PACKING RINGS



R/M Vee-Flex packing rings insure a positive and long-lasting seal against fluids. Different types are available to meet special conditions, as in the food, chemical and oil industries. Rings are manufactured in diameters up to several feet and with annular width graduated from ¼" to 1½".

Vee-Flex rings nest together so that several rings can be fitted into a shallow stuffing box. Each ring operates as a separate seal to control pressure and the greater the number of rings in a set, the greater the effectiveness of the seal and the longer the service life.

Vee-Flex rings are used successfully on all types of oscillating, reciprocating and rotating shafts, on valve stems, airplane shock absorbers, hydraulic presses and elevators, triplex pumps, inside-packed pumps, accumulators and telemotors.

For full information write for your free copy of the latest Vee-Flex bulletin.

***IT'S "PACKED WITH SATISFACTION" WHEN YOU USE* R/M**

RAYBESTOS-MANHATTAN, INC.

ASBESTOS TEXTILE & PACKING DIVISION

Manheim, Pa. • Bridgeport, Conn. • North Charleston, S. C. • Passaic, N. J.

WE ALSO MANUFACTURE A COMPLETE LINE OF ASBESTOS TEXTILES, FRICTION MATERIALS, AND INDUSTRIAL RUBBER PRODUCTS.

R M

PROFESSIONAL SERVICES

THE CARLSON COMPANY
Spring Design Specialists
MECHANICAL PRODUCT DEVELOPMENT
277 Broadway — New York 7, N. Y.
Barclay 7-2552

YOUR card here builds prestige for you and helps to make your name familiar in the field. The cost is extremely small in proportion to its value as a business aid.

M. ROSENBLATT & SON
All Types Drafting & Design
Contract & Hourly Rates
111 Broadway — New York 6, N. Y.
BEekman 3-7430

EGERTON DESIGN SERVICE
Mechanical Design • Drafting
Scheduled or Excess Drafting
617 State Street — Traverse City, Mich.

LANCASTER ALLWINE & ROMMEL
REGISTERED PATENT ATTORNEYS
Patent Practice before U. S. Patent Office. Validity and Infringement Investigations and Opinions. Booklet and form "Evidence of Conception" forwarded upon request.
Suite 461, 815-15th St. N.W., Washington 5, D. C.

TECH-DRAFTING SERVICE CO.
DESIGNERS DRAFTSMEN
SURPLUS & REGULAR DRAFTING
DESIGN & DETAILING
ALL BRANCHES ENGINEERING
5 Beekman St. — Worth 4-5073 — N. Y. 7, N. Y.

FAVREX DESIGNS
Mechanical drafting, machine tool design, tooling, special machinery, new apparatus, large technical staff will handle complete development from simple idea to detailed drawings.
Offices: Paris-France and Hasbrouck Heights, N. J.
526 Burton Avenue, Hasbrouck Heights, N. J.

GEORGE H. KENDALL
Consulting Mechanical Engineer
Cost Reduction Studies: Process or Product.
Redesign Existing Products for Greater Profit.
Trouble Shooting Production, Design, Cost Problems.
Specialist Automatic Machinery, Processes, Controls.
New Developments, Patent Studies, Investigations.
New Products & Process Engineering Studies
P. O. Box 72 (*Est. 1923*) Tel. Darien 5-1504
Noroton Heights — Darien, Connecticut

JOHN C. VAN RIPER
GEARING ENGINEER
Mechanical Transmission Design
Four Station Square — Rutherford, N. J.

HERMAN LEWIS GORDON
Registered Patent Attorney
Patent Investigations and Opinions
Warner Building, Washington 4, D. C. NAtional 2497
100 Normandy Drive, Silver Spring, Md. SHepherd 2433

NEW YORK TESTING LABORATORIES, INC.
CHEMICAL, MECHANICAL, ELECTRICAL METALLURGICAL ENGINEERS
ANALYTICAL CHEMISTS, PHYSICISTS, X-RAY
Analysis, Tests of all Materials and Products. Plant and Field Services in Special Measurements of Stress, Sound, Vibration and other. Consultants in Litigation and Process Engineering and Design.
80 Washington St. — New York City 6, N. Y.

CHARLES VESELY & ASSOCIATES, INC.
Industrial Designers and Engineers
Design — Consumers Products
Engineering — Commercial Equipment
Product Development — Durable Goods
197-N. 123rd Street, Wauwatosa 13, Wisconsin

SEARCHLIGHT SECTION
(Classified Advertising)

EMPLOYMENT : "OPPORTUNITIES" : EQUIPMENT
BUSINESS : : (Used or Resale)

UNDISPLAYED —RATES— DISPLAYED

(Not available for equipment advertising)
$1.20 a Line, minimum 4 lines. To figure advance payment allow 5 average words to a line.
Positions Wanted (full or part time salaried employment only), ½ the above rates payable in advance.
Box Numbers—Care of publication New York, Chicago or San Francisco offices as one line.
Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Individual Spaces with border rules for prominent display of advertisements.

The advertising rate is $8.75 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

P.E.

ENGINEERS–

Rapidly expanding Engineering Department of North American Aviation, Inc., needs qualified

AERODYNAMICISTS
THERMODYNAMICISTS
STRESS ANALYSTS
AIRCRAFT DESIGNERS

and specialists in all phases of aircraft engineering, for work on military projects. Experience in fields other than aircraft engineering may be adaptable. Please include summary of experience in reply.

Engineering Personnel Office
NORTH AMERICAN AVIATION, INC.
Los Angeles Airport,
Los Angeles 45, Calif.

ENGINEERS
DESIGN — TEST — EXPERIMENTAL
Midwestern manufacturer of 2-cycle engines has openings for ambitious engineers. Experience in 2-cycle engines and/or magneto ignition desirable.
P 6955 Product Engineering
520 North Michigan Ave., Chicago 11, Ill.

When Writing Your Ad

Provide an indexing or subject word. Write it as the first word of your ad. If it is a Position Wanted or Position Vacant ad, make the first word the kind of position sought or offered. The right is reserved to reject or revise all Want Advertisements.

Classified Advertising Division
PRODUCT ENGINEERING

Exceptional Opening for SALES ENGINEER
to cover Mid-West Metalworking Industry

Selling Experience Desirable But Not Essential

Nationally known manufacturer of fastening devices wants man to advise customers on applications—not take orders—working in mid-west with headquarters preferably in St. Louis or Kansas City. Salary to be commensurate with experience.

Requirements: Varied knowledge of metalworking production gained by plant work or selling; ability to travel extensively away from home. Write in detail about background. Interview arranged at New York headquarters; expenses paid.

RW 7272 Product Engineering
330 West 42nd St., New York 18, N. Y.

MACHINE DESIGNER, M. E.,
For development engineering division of well established S. E. Penna. cmpany. Must be experienced in design of processing and other machinery. Advise education, experience and salary requirements.
P 7441, Product Engineering
330 West 42 St., New York 18, N. Y.

SEARCHLIGHT SECTION

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (18)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

WANTED—ENGINEERS—Expanding southern industry has openings for mechanical engineer for machine design, mechanical and process development work. Please give in first letter full details of education, age, experience, qualifications, references, availability, and salary desired. P-6735, Product Engineering.

RESEARCH ENGINEERS: With degree in Mechanical Engineering or Physics and five to ten years experience in research or development work. For applied research on the flow of water, steam and air; metals under simulated service conditions; heat transfer; experimental stress analysis; all as applied to steam boilers and related equipment. Unusual opportunity for men in new research and development laboratory. The Babcock and Wilcox Co., Research & Development Department, Alliance, Ohio.

ENGINEER FOR design and installation of steam and electrical equipment in new plant of expanding industry. After construction, man selected will have possible opportunity as plant engineer. Complete information required in first letter. All details confidential. P-6783, Product Engineering.

RESEARCH DESIGNER: For the design of experimental apparatus. Each apparatus is designed individually to provide the conditions desired for the specific problem. These problems deal with applied research on heat transfer; metals under simulated service conditions; flow of water, steam and air, experimental stress analysis. Degree in engineering or physics with about five years experience in research or development is desirable. The Babcock and Wilcox Co., Research & Development Department, Alliance, Ohio.

DESIGN DRAFTSMAN: Old established Philadelphia manufacturer has opening for man with considerable experience and creative ability on design and development small mechanisms for mass production. Experience on small stampings, plastics and die castings, as used in automotive accessories, household appliances, etc., very necessary. Give all details in first letter, which will be treated confidentially. P-7090, Product Engineering.

ENGINEER—FOR general engineering and product development work. Responsible position with good future, requiring experience and engineering education. Domestic Electric Appliances. Plant Northwestern Ohio. Housing can be furnished. P-7393, Product Engineering.

WANTED: MECHANICAL Engineer with 5 years experience in stress analysis and mechanical design of rotating Electrical Equipment. Must be capable of supervising design and drafting personnel. Excellent opportunity for qualified man with long established Midwestern concern. P-7409, Product Engineering.

EMPLOYMENT SERVICES

SALARIED POSITIONS $3,500-$35,000. If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (38 years recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 268 Dun Bldg., Buffalo 2, N. Y.

SALARIED PERSONNEL $3,000-$25,000. This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. H, 241 Orange St., New Haven, Conn.

POSITIONS WANTED

MECHANICAL ENGINEER for product machine design. Former plant engineer with supervisory, production and practical shop background. Experienced in original design of medium and heavy machinery including chemical process and production tool equipment, conveyors, geared transmissions, hydraulics, and road machinery. Married, age 33, now employed. Desires position requiring responsibility, initiative, organizational ability and creative effort with a small organization in the Indiana or Ohio area. PW-7353, Product Engineering.

MECHANICAL DESIGNER. Fifteen years experience in the design and development of machinery and processing equipment. Age 35. Technical graduate. Prefer position with a concern manufacturing farm tractors or allied equipment. PW-7370, Product Engineering.

WANTED

a versatile engineer for one of engineering's most versatile jobs

This is an unusually interesting opportunity for a graduate mechanical engineer who feels confident of his ability to be good at other things, too.

Are you a good engineer?

Have you been successful as a design engineer?

Do you enjoy meeting other engineers and finding out what makes their products good?

Can you write clearly and interestingly about new ideas and techniques in product design . . . in engineering terms for the benefit of other engineers?

Do you like to travel sometimes . . . dig into interesting problems . . . work on your own, and spark ideas?

Do you have imagination and the ability to interpret new engineering developments in terms of their commercial potentials?

If your answer to these questions is "yes," we think you will want to talk with us. So write today and tell us about your education, your experience, your age, and tell us something about your ability to write clearly and interestingly about engineering or technical subjects. Your letter will be held in strictest confidence.

P-7454, Product Engineering
330 West 42nd Street, New York 18, N. Y.

STRESS ANALYSTS

Stress Analysts: Graduate in mechanical engineering or physics with five to ten years experience in theoretical or experimental stress analysis, preferably on pressure vessels and heat exchange equipment. Knowledge of thermal stresses desirable. Excellent opportunity for qualified man in new Research and Development Department Laboratory. Write, giving resume of education and experience.

THE BABCOCK & WILCOX COMPANY
Research & Development Department,
ALLIANCE, OHIO

POSITIONS WANTED

ENGINEER—MECHANICAL-Industrial 30, 10 years broad experience machine design, product design, production methods, efficiency cost and maintenance. Dies, tools and structural design. Responsible supervisory experience. PW-7440, Product Engineering.

PATENT ATTORNEY 44 seeks connection with aggressive company in mechanical field. Over 18 years varied patent experience including preparations, prosecutions, patent and industrial surveys, investigations, negotiations etc. Can set up new patent department if desired. PW-7464, Product Engineering.

SELLING OPPORTUNITY WANTED

SALES ENGINEER of Factory Representative, 34, single, ambitious, graduate E.E. M.E., unusually broad education, languages, able negotiator, seeks connection with reputable manufacturer of electromechanical apparatus on salary and commission basis. SA-7354, Product Engineering.

BUSINESS OPPORTUNITY

Wanted: Manufacturer of quality power transmission products is seeking associated or other mechanical devices of merit, to manufacture and market. Address BO-7247, Product Engineering.

PRODUCT DESIGN and Styling
ETTEL INDUSTRIAL DESIGN
112 South 106th Street
Seattle 88, Washington

The Very Best Facilities For . . .
METAL STAMPINGS
IN SMALL LOTS
DAYTON ROGERS
Manufacturing Company
Minneapolis 7, Minn.

DYNAMIC BALANCING

We dynamically balance any high speed rotating part, regardless of configuration, to a degree measurable only in micro ounce inches. Perfect balance will increase bearing life and insure better performance. It is essential to your product. Gyro rotors of all types are a specialty. Let us handle your balancing problems.

MICRO BALANCING, INC.
116 Rintin St. Franklin Square, N. Y.

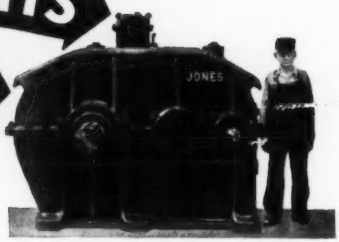
PRODUCTION ★ ★ ILLUSTRATION
MECHANICALS & VISUALS
CUTAWAYS & RENDERINGS
OF ALL TYPES
INQUIRIES INVITED
CW 7405 Product Engineering
330 West 42nd St., New York 18, N. Y.

"Powered by the Magic of the Spinning Flame"
Licenses available on royalty
U. S. Patent 2446473
Hanna Whirlwind Burner
M. E. HANNA, 218 W. CENTRAL
Albuquerque, N. Mex.

FOR SALE
Model 600 DeLaval Separator
for $250.00 F.O.B. Our Plant—Not Crated. Suitable for removing particles from waxes or liquids.
R. E. Worden
DICTAPHONE CORPORATION
375 Howard Ave., Bridgeport, Conn.

New "SEARCHLIGHT" Advertisements received by 10:00 A.M. January 20th will appear in the February issue, subject to space limitations.
Classified Advertising Division
PRODUCT ENGINEERING
330 W. 42nd St., New York 18, N. Y.

Whether you need THIS —or THIS



You can get what you want in the complete range of Jones Herringbone Speed Reducers

YOU will find this 128-page catalog of Jones Herringbone Speed Reducers helpful in the selection of reducers in accordance with A.G.M.A. recommended practice for all conditions of service. Jones Herringbone Speed Reducers are built in single, double and triple reduction types and in every standard ratio in ratings ranging from 1.25 H.P. to 440 H.P.

All these reducers have heat treated gears, ground shafts and are mounted with anti-friction bearings throughout. Liberal stocks are carried to facilitate shipments.

Catalog No. 70 will save you time and effort in laying out drives that call for Herringbone gears.

WRITE FOR YOUR FREE COPY

W. A. JONES FOUNDRY & MACHINE CO., 4417 Roosevelt Rd., Chicago, Ill.

Jones HERRINGBONE—WORM—SPUR—GEAR SPEED REDUCERS • PULLEYS
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

THERE'S A RIGHT LOCK NUT FOR YOUR JOB!

Chances are four out of five it's An-cor-lox. Check these advantages!

Can't shake loose	Competitively priced
Not affected by sawed-off or drilled bolts	Spins on stud by hand
Can be re-used many times	Locking ring forms a pressure seal
Locking ring on bottom, uses short stud	Not affected by temperature
Uses standard wrenches	Choice of finishes for corrosive or severe atmospheric conditions
Won't damage bolt or work	

Get the right lock nut! We strongly urge a careful testing and will be glad to have our engineers check special applications. Send today for our descriptive folder or free standard samples to fit your particular needs.

An-cor-lox TRADE MARK REGISTERED *Lock Nuts*

LAMINATED SHIM CO., Inc., *An-cor-lox Division*, 1401 Union St., Glenbrook, Conn.

AN-COR-LOX NUTS • SHIMS • SHIM STOCK • STAMPINGS

The Latest News of Science Now Yours in One Big Magazine!

Now at last you can keep up with the new inventions and discoveries of science that affect you and your industry. Every month *Science Illustrated* is filled with new advances in vital fields... Electricity, Construction, Aviation, Atomic Energy, Radio, Synthetics, Mining, Chemistry, Electronics, Home Appliances, etc.

Science Illustrated shows you new products and designs and explains *why*, *when* and *how* they were made. Every monthly issue is packed with 30 complete, authentic articles and 140 photographs, diagrams.

ORDER NOW AND SAVE $4!

You can order 36 big issues of *Science Illustrated* (3 full years) for ONLY $5! This special rate *saves you* $4 over the one-year price. We'll start your subscription with the big new issue now on the press—*if you order within 10 days!*

MAIL THIS ORDER FORM TODAY!

Science Illustrated
330 West 42nd Street, N. Y. 18, N. Y.

YES! I accept your special offer. Start my subscription to Science Illustrated with the new issue now on press.

☐ I prefer 2 yrs. at $4 (Saves me $2 compared with the 1-yr. rate)
☐ I prefer 3 yrs. at $5 (Saves me $4)
☐ I prefer 1 yr. at $3
☐ Bill me later ☐ Payment enclosed

Name _____

Address _____

City _____ Zone _____ State _____

ALSO ON SALE AT ALL NEWSSTANDS 25¢

FPE-1-49

INDEX OF *Products Advertised* IN THIS ISSUE

MATERIALS

Aluminum Alloys 257
Bimetal 304
Brass 8, 66–67
Bronze 66–67, 234, 261, 311
Carbon 208
Copper Alloys 8, 66–67, 281
Graphite 20–21, 32
Laminated Metals 33, 60, 217
Leather 241
Magnesium Alloys 232, 239
Molybdenum Alloys 268
Nickel Alloys ..... 2nd Cover, 38, 44, 66–67 177, 261, 266, 281
Nylon 252
Paper 171
Phospher Bronze 231, 298
Plastics 17, 23, 26, 32A, 33, 61, 70–71 196, 213, 263, 265, 274, 277, 300
Powdered Metals 63
Rubber & Synthetics 13, 196, 299
Silicones 186, 300
Stainless Steel 18, 36–37, 44, 64A, 230 294–295
Steel 43, 48, 164, 168, 185, 291
Tungsten Carbide 288
Wood 217, 247, 279
Zinc 76

STRUCTURAL PARTS

Castings 31, 234, 257, 264, 272, 286 302, 318
Die Castings 12, 76, 162, 186, 194 204, 207
Forgings 8, 235, 270, 296, 310
Metal Powder Parts 63
Rods 252, 300
Stampings 188, 249
Tubing 18, 41, 54, 192, 197, 271, 310
Wire 220

FINISHES

Galvanizing 216
Paints & Lacquers 173
Rust Proofing 198, 287

MECHANICAL PARTS

Bearings, Ball, Roller, and Needle 4th Cover, 9, 32, 46, 51, 77, 80, 166
Bearings, Sleeve 166, 223, 261, 290, 311
Bellows 30, 55 202, 211, 236, 251, 301, 307, 314
Belts 28–29, 199, 237, 250
Bolts, Nuts, Screws and Rivets 6 19, 22, 34, 39, 56–57, 59, 65, 73, 74, 175 189, 200, 210, 224, 300, 318, 324
Brushes 208
Chains 64B, 68–69, 212, 238, 275
Clutches 35, 215, 234, 240, 274, 275 330
Compressors 199
Containers 297
Controls 62
Couplings, Flexible 68–69, 190, 219
Couplings, Hose & Tube 219, 233, 267
Engines 274, 302
Fan Blades 251, 282
Fastenings 6, 19, 22, 34, 39, 56–57 59, 65, 73, 74, 175, 189, 190, 200 210, 224, 300, 318, 324
Filters 258, 278
Flexible Joints 319
Gages 47, 62, 203
Gears 49, 52, 75, 194, 221, 242, 246 255, 258, 262, 276, 292, 313
Hose 233
Hydraulic & Pneumatic Equipment 4, 14–15, 27, 50, 62, 222, 227 269, 275, 293, 302, 330
Joints 242, 244
Lubricating Equipment 209, 258, 289 317
Mountings 205
Name Plates 314
Packing, Gaskets, Seals 20–21, 53, 187 214, 241, 289, 306, 310, 321
Plastic Machinery 203
Pumps 28–29, 199, 203, 220, 238, 248 253, 292, 293, 304, 308
Rings 19, 306, 321
Seats 262
Shafts 280, 312
Sheaves & Pulleys 31, 199, 330
Shims 324
Silicones 186, 300
Sockets 309
Speed Reducers & Motor Reducers 14–15, 246, 324
Springs 42, 188, 242, 328
Thermostats 32B, 55, 304, 320
Timers 193, 286
Transmissions ..... 3rd Cover, 14–15, 52 199, 256, 275, 293
Valves & Fittings 62, 181, 218, 252 256, 264, 273, 276, 278, 289, 293, 310 326
Vibration Dampers 16, 205
Wheels & Casters 238
Wire Cloth 64, 250, 266, 268

ELECTRICAL PARTS

Assemblies 78
Brake 35
Contacts 2, 16, 40, 78, 248, 256
Controls & Control Equipment 2 10-11, 16, 24-25, 28-29, 182-183, 191 195, 216, 228, 245, 259-260, 282
Electronic Equipment 16, 245
Generators 244
Instruments 45, 193, 229, 308
Insulators 302
Lamps 248
Magnets 284
Motors ..... 3rd Cover, 28-29, 231, 243 244 254, 276, 280, 282
Rectifiers 2, 16, 308
Transformers 244
Wire & Cable 58, 238
Wiring Accessories 58, 248, 254

DRAFTING ROOM EQUIPMENT AND SUPPLIES

72, 171, 184, 201, 292, 318

FABRICATING METHODS AND SERVICES

Assembling 186
Balancing 234
Bending 179
Brazing 283
Forming 179
Grinding 221
Heating 262
Molding 17, 23, 26, 32A, 33, 61, 70-71 196, 213, 263, 265, 274, 277, 300
Pressing 219, 247, 279
Spinning 306
Stamping 188, 248, 249, 258, 328
Swaging 258
Welding 188, 206, 316, 285

ENGINEERING AND PRODUCTION SERVICES

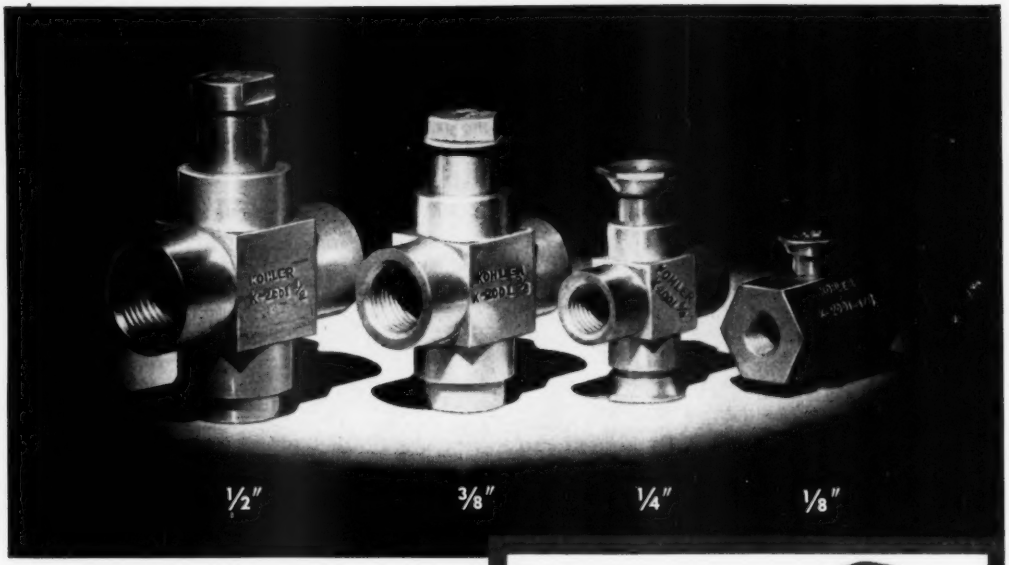
184, 185, 303, 322

BOOKS

193, 228, 246, 250

TRANSPORTATION

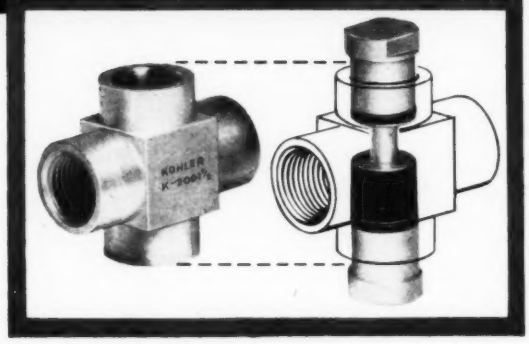
236



Positive Control for Vacuum and Air Lines

•

Precision Made Leakproof



KOHLER ON-OFF VALVE

Kohler K-2001 valves can be easily adapted to all installations, and will positively control vacuum and air.

Stringent tests are applied to each valve before shipment. All rubber seals are specially lubricated for vacuum and air use to insure long, easy operation. Connections can be furnished as desired in the sizes illustrated above—each of which shows 2 internal pipe threads. K-2001 valves are designed for long hard use and have proved themselves on many different applications. Rugged, simplified design makes operation easy—you merely *push on; push off.*

The complete line of Kohler precision parts includes hand engine primers, check valves, plug valves, angle needle valves, air valves, restrictor valves, snubber valves and many fittings—all backed by the 76-year-old Kohler quality tradition. Prompt deliveries are assured by complete facilities, in one plant for die-casting brass, aluminum or white metal, sand-casting, forging, machining, plating and anodyzing. Kohler engineers will gladly develop valves for your special requirements. Kohler Co., Dept. 8-J, Kohler, Wisconsin.

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS

ADVERTISERS INDEX

Advance Foundry Co. 318
Advance Paint Co. 173
Aeroquip Corp. 267
Aetna Ball & Roller Bearing Co. 236
Air Express Division of Railway Express Agency 236
Allegheny Ludlum Steel Corp. 230
Allen-Bradley Co. 259-260
Allied Research Products, Inc. 198
Allis-Chalmers Mfg. Co. 28-29
Aluminum Co. of America Fasteners 39
Aluminum Industries, Inc. 257
American Chain & Cable Co., Inc. 202, 313
American Hard Rubber Co. 196
American Hot Dip Galvanizers Assn. 216
American Machine Metals, Inc. United States Gauge 47
American Magnesium Corp. 232
American Manganese Bronze Co. 234
American Metal Hose Branch, American Brass Co. 233
American Nickeloid Co. 177
American Screw Co. 65, 73
American Steel & Wire Co. 294-295
American Welding & Mfg. Co. 285
Amplex Mfg. Co., Div. Chrysler Corp. 166
Armco Steel Corp. 164
Armstrong Cork Co. 53
Austenal Laboratories, Inc. 272
Automotive & Aircraft Div. of Amer. Chain Co., Inc. 238
Automotive Gear Works, Inc. 313

Bakelite Corp. 26
Baldwin-Duckworth Div. Chain Belt Co. 68-69
Barco Manufacturing Co. 319
Barnes Co., Wallace Div. Associated Spring Co. 42
Barnes Gibson Raymond Div., Associated Spring Co. 242
Bath Co., Cyril 179
Bear Manufacturing Co. 234
Bethlehem Steel Corp. 48
Bijur Lubricating Corp. 317
Blackmer Pump Co. 253
Boeing Airplane Co. 303
Boston Gear Works 246
Brady Products, Inc., F. E. 304
Bridgeport Brass Co. 66-67
Brown Instrument Company 229
Bruning Co., Inc., Charles 72
Bundy Tubing Co. 271
Bunting Brass & Bronze Co. 311

Cambridge Wire Cloth Co. 250
Camcar Products Co. 65
Carlyle Johnson Machine Co. 215
Carnegie-Illinois Steel Corp. 294-295
Carpenter Steel Co. 36-37
Cash Valve Mfg. Corp., A. W. 310
Celanese Corp. of America 70-71
Central Screw Co. 65
Chace Co., W. M. 304
Char-Lynn Co. 194
Cherry Rivet Co. 22
Chicago Rawhide Mfg. Co. 241
Clare & Co., C. P. 195
Clifford Mfg. Co. 30
Climax Molybdenum Co. 268
Columbia Steel Co. 294-295
Continental Screw Co. 65
Corbin Screw Div. of American Hdwe. Corp. 65
Crane Company 181
Curtis Universal Joint Co. 244

Dayton Rogers Mfg. Co. 318
Dayton Rubber Manufacturing Co. 237
De Laval Steam Turbine Co. 238
Delco Products Div. Gen. Mtrs. Corp. 231
Denison Engineering Co. 252
Dial Light Co. of America 248
Diefendorf Gear Corp. 242
Dodge Mfg. Corp. 314
Doehler Jarvis Corp. 12
Dow Chemical Co. 239, 263
Dow Corning Corp. 186
Driver-Harris Co. 245
Drop Forging Association 235
Durez Plastics & Chemicals, Inc. 61

Eastern Industries Inc. 292
Eastman Kodak Co. 201
Eaton Mfg. Co., Foundry Division 31
Eaton Mfg. Co.-Reliance Spring Washer Div. 19
Elco Tool & Screw Corp. 65
Electric Auto-Lite Co. 162
Electric Specialty Co. 244
Emerson Electric Mfg. Co. 254
Engineering Products Co. 302
Excello Corp. 227

Fafnir Bearing Co. 211
Fairfield Mfg. Co. 292
Fansteel Metallurgical Corp. 40
Farrel-Birmingham Co., Inc. 255
Fasco Industries, Inc. 282
Fawick Airflex Co. 240
Federal Bearings Co., Inc. 46
Federal-Mogul Corp. (Equipment) 223
Fenwal, Inc. 320
Flexo Supply Co. 242
Foote Bros. Gear & Machine Corp. 52
French & Hecht, Inc. 238
Fulton Sylphon Div. Robertshaw-Fulton Controls Co. 55

Galland-Henning Mfg. Co. 278
Garrett Co., Geo. K. 188
Gast Mfg. Corp. 220
Gear Grinding Machine Co. 221
Gear Specialties 49
General American Transportation Corp. Plastics Div. 265
General Controls Co. 218
General Electric Co., Apparatus Dept. 10-11
General Electric Co., Appliance & Merchandise Dept. 58
General Electric Co., Plastics 23
General Electric Co., Chemical Dept. Silicones 300
General Plate Co. 60
Gerotor May Corp. 50
Gits Bros. Mfg. Co. 289
Gleason Works 4
Goodrich Co., B. F. (Rivnut) 6
Goodrich Chemical Co., B. F. (Hycar) 13
Gray Iron Founders' Society Inc. 270
Great Lakes Div., National Steel Corp. 168

Handy & Harman 283
Hanna Engineering Works 269
Hannifin Corporation 258, 289
Hansen Mfg. Co., Inc. 286
Harper Co., H. M. 65
Harrington & King Perforating Co. 262
Hartford Special Machinery Co. 262
Haskelite Mfg. Corp. 217
Haydon Mfg. Co. 193
Haynes Stellite Co. 266
Hevi Duty Electric Co. 244
Hilliard Corp. 234
Holliston Mills 184
Holo-Krome Screw Corp. 224
Houghton & Co., E. F. 214
Hyatt Bearings Div., Gen. Mtrs. Corp. 51

Illinois Coil Spring Co. 188
Indiana Steel Products Co. 284
International Nickel Co., Inc. Monel 38
International Nickel Co., Inc. (Nickel Alloy) ..... 2nd Cover
International Rolling Mill Products Corp. 291

Johnson Bronze Co. 290
Johnson Machine Co., Carlyle 215
Jones Foundry & Machine Co., W. A. 324

Kohler Co. 326
Koppers Co., Inc., (Fast's Coupling) 219
Koppers Co., Inc.—Plastics Div. 213
Koven & Bro., Inc., L. O. 249
Kurz-Kasch, Inc. 277

Lamb Electric Co. 243
Laminated Shim Co., Inc., (Ancorlox) 324
Lamson & Sessions Co. 65
Lauson Co. 302
Lincoln Electric Co. 316
Lincoln Engineering Co. 209
Linear, Inc. 310
Link-Belt Co. 9
Lombard Governor Corp. 256
Lord Mfg. Co. 205

RAYMOND FOR DELIVERIES
RAYMOND FOR SAMPLES
RAYMOND FOR RESEARCH
RAYMOND FOR RESULTS

THEY ALL AGREE . . . . .

For whatever reason you may select a springmaker, Raymond meets that requirement—plus. If you design, specify or buy springs, you'll find it pays to call Raymond—for prices, prompt production or helpful advice.

ADVERTISERS INDEX

Lukens Steel Co. (Clad Steel)... 44
Lukens Steel Co. (Flanging & Pressing) 34

McGill Mfg. Co., Inc. 307
McGraw-Hill Book Co., Inc. 250
Madison-Kipp Corp. 204
Mahon Co., R. C. 206
Mallory & Co., Inc., P. R. 2, 16
Mansfield & Green 276
Martin-Hubbard Corp. 184
Masonite Corporation 279
Master Electric Co. Speedmaster 3rd Cover
Metal Carbides Corp. 288
Metron Instrument Co. 308
Michigan Steel Tube Products 197
Micro Switch Div. of First Industrial Corp. 191
Midwest Molding & Mfg. Co. 300
Milford Rivet & Machine Co. 65
Mills Corp., Elmer E. 32A
Milsco Mfg. Co. 262
Monsanto Chemical Co. 17
Moraine Products Div. General Motors 63
Morganite, Inc. 264
Morse Chain Co. 275
Morse Co., Frank W. 309
Mt. Vernon Die Casting Corp. 207

National Bearing Div., American Brake Shoe Co. 202
National Lock Co. 65
National Lock Washer Co. (Retaining Rings) 189
National Motor Bearing Co., Inc. 187
National Screw & Mfg. Co. 65, 210
National Steel Corp. ..... 6 A, 168
New Departure Div. of Gen. Motors Corp. 80
New England Screw Co. 65
New Jersey Zinc Co. 76
Newton Industries Inc. 186
Nicholson & Co., W. H. 256
Nikoh Tube Co. 291
Norgren Co., Inc. C. A. 278
Northern Industrial Chemical Co. 274

Ohio Precision Casting Co. 264
Orange Roller Bearing Co., Inc. ... 251

Page Steel & Wire Div., Amer. Chain & Cable Co. Inc. 220
Parker-Kalon Corp. 65, 74
Parker Rust Proof Co. 287
Patton-MacGuyer Co. 278
Pawtucket Screw Co. 65
Peerless Electric Co. 276
Penn Metal Co., Inc. 268
Pheoll Manufacturing Co. 65
Philadelphia Gear Works 75
Phillips Screw Manufacturers 65
Phosphor Bronze Corp. 298
Plastic & Rubber Products, Inc. ... 306
Polymer Corp. 252
Power Equipment Co. 216
Pressco Casting & Mfg. Corp. 286
Progressive Mfg. Co. 300

R.B.M. Division of the Essex Wire Corp. 256
Radio Receptor Co. 308
Raybestos-Manhattan Inc. Packing Division 321
Raymond Mfg. Co., Div. Associated Spring Co. 328
Reading Screw Co. 65
Redmond Co., Inc. 280
Reeves Pulley Co. 14-15
Republic Steel Corporation (Steel & Tubes Div.) 18
Revere Copper & Brass Inc. 8
Reynolds Wire Co. 64
Riegel Paper Corp. 171
Riverside Metal Co. 281
Rockford Clutch Div., Borg-Warner 274
Rockford Screw Products Co. 65
Roehr Products Co. 310
Roland Teiner Co. 306
Ross Operating Valve Co. 273
Russell Burdsall & Ward 65

Sandvik Steel, Inc. 185
Schrader's Son, A. Div. Scovill Mfg. Co. 62
Scovill Mfg. Co. Industrial Fasteners 200
Scovill Mfg. 65
Seaboard Screw Corp. 65
Sewall Mfg. Co., E. B. 194
Shakeproof Inc. 65
Sharon Steel Corp. 43
Shenango-Penn Mold Co. 261
Sier Bath Gear & Pump Co. 258
Southington Hardware Mfg. Co. .. 65
Spencer Thermostat Co. 32B
Sponge Rubber Products Co. 299
Square D Co. 24 25
Stackpole Carbon Co. 208
Standard Pressed Steel Co. 56-57, 318
Steel Co. of Canada, Ltd. 65
Sterling Bolt Co. 65
Stokes Machine Co., F. J. 203
Stronghold Screw Products, Inc. 65
Struthers Dunn Inc. 228
Sundstrand Machine Tool Co. 293
Superior Tube Co. 192
Sweet's Catalog Service .. 193, 228, 246

Tempil Corp. 292
Tennessee Coal, Iron & Railroad Co. 294-295
Thomas Flexible Coupling Co. 190
Thomson Industries, Inc. 301
Timken Roller Bearing Co. .. 4th Cover
Timken Roller Bearing Co. (Steel & Tubes Div.) 41
Tinnerman Products Inc. 59
Tomkins-Johnson Co. 222
Torrington Co. 258
Torrington Co. (Needle Bearings) 77
Tuthill Pump Co. 308
Twin Disc Clutch Co. 330

Union Carbide & Carbon Corp. 26, 266
Union Chain & Mfg. Co. 212
United-Carr Fastener Corp. 190
United Screw & Bolt Corp. 175
U. S. Gauge Div., American Machine & Metals Inc. 47
U. S. Graphite Co. 20-21, 32
U. S. Steel Corp. 294-295
U. S. Steel Export Co. 294-295
U. S. Steel Supply Co. 294-295
Universal Clay Products Co. 302

Vickers, Inc. 27
Viking Pump Co. 248

Wales-Beech Corp. 65
Walker-Turner Division, Kearny & Trecker Corp. 280
Ward Leonard Electric Co. 182-183
Warner Electric Brake Mfg. Co. 35
Watson-Flagg Machine Co. 276
Weirton Steel Co. 64A
Westinghouse Electric Corp. 33, 45
Wheland Co. 302
White Dental Mfg. Co. S. S. 312
Whitney Chain & Mfg. Co. 64B
Williams Co., J. H. 310
Willys-Overland Motors, Inc. 296
Wilson Co., H. A. 78
Wirebound Box Mfgrs. Assoc. 297
Wisconsin Motor Corp. 274
Wolverine Bolt Co. 65
Wolverine Tube Div. Calumet & Hecla Cons. Copper Co. 54
Woodall Industries, Inc. 247
Worthington Pump & Machinery Corp. 199

■

PROFESSIONAL SERVICES 322

■

SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT
Positions Vacant 322, 323
Selling Opportunities Offered 322
Positions Wanted 323
Selling Opportunities Wanted 323
Employment Services 323

SPECIAL SERVICES
Contract Work 323
Rebuilding 323

BUSINESS OPPORTUNITIES
Offered 323

EQUIPMENT
(Used or Surplus New)
For Sale 323

Fluid Power

IN A PACKAGE

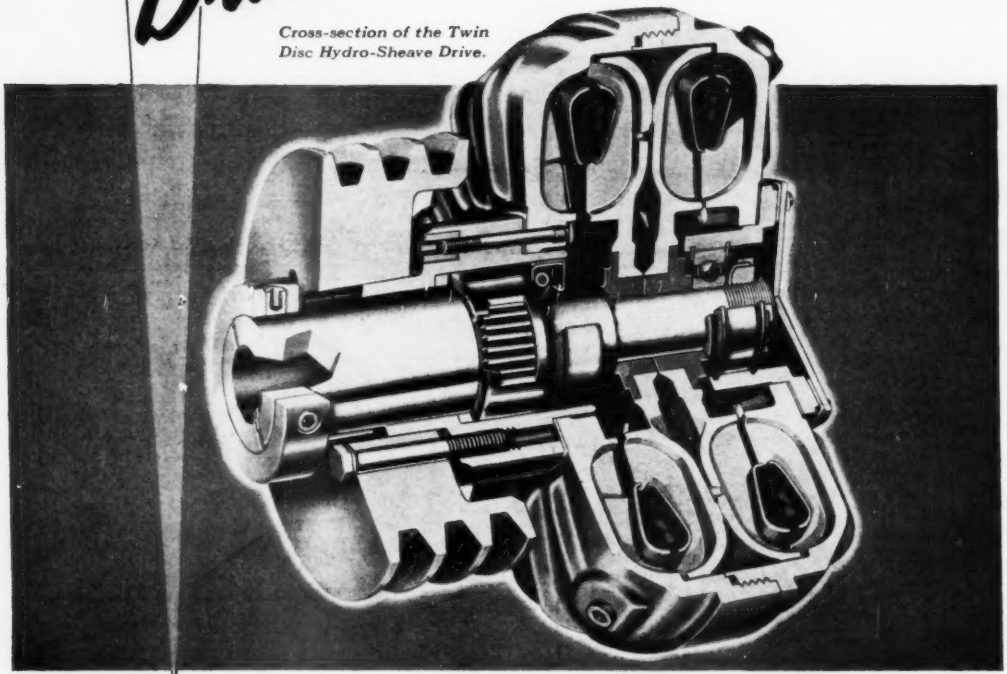
the New Hydro-Sheave Drive

☆ The simplest and most economical fluid power transmission available today is the new Twin Disc Hydro-Sheave Drive . . . you buy it in a convenient package, less the sheave.

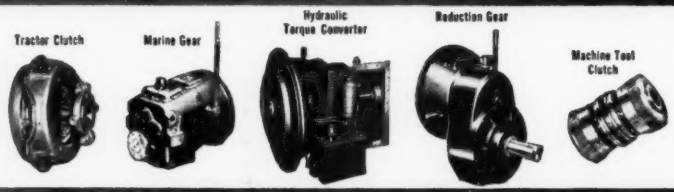
Twin Disc Hydro-Sheave Drive offers the operator of small power units all the advantages of a fluid drive in a low-cost conversion device no more difficult to apply than a sheave. The sleeve of the Hydro-Sheave slides over the output shaft of your power unit where it is held in place by three set screws. The package is complete with installation instructions, parts drawings, parts list and the wrench required for mounting.

Designed especially for use with Worthington QD sheaves on electric motors and small internal combustion engines in the $\frac{3}{4}$ to 25 hp range, Twin Disc Hydro-Sheave Drive is available in five sizes. For complete information, including price and the name of your nearest distributor, write the Hydraulic Division for a copy of Bulletin 145. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

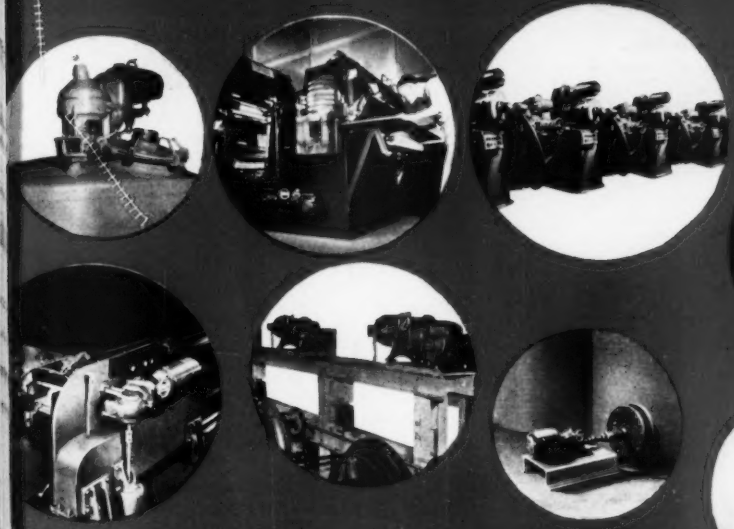
Cross-section of the Twin Disc Hydro-Sheave Drive.



TWIN DISC
HYDRO-SHEAVE DRIVES



SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918



On thousands of applications, stepless variable speed operation assures exactly the right speed for every operation . . . for each operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation pays off in higher rates of production, a better quality product and more efficient performance of your equipment and your operators.

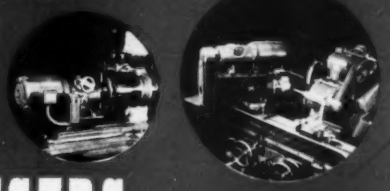
variable speed operation doesn't cost

IT PAYS

Master Speedrangers provide this infinitely variable speed in compact, all-metal, mechanical variable speed units in a wide range of types and sizes up to 5 horsepower.

See how the Speedrangers on the applications shown incorporate an electric motor, a variable speed unit, a gear reduction, and an electric brake . . . all standard Master units that easily combine into a compact, integral power drive. This provides exactly the right speed, the right features, in a unit that you can use right where you want it.

Write for Data 7525, a new 24-page book on Speedrangers, and see what a real job they can do for you.



MASTER SPEEDRANGERS

THE MASTER ELECTRIC COMPANY · DAYTON 1, OHIO

NEW STANDARDS of ACCURACY made possible by NEW TIMKEN® BEARINGS!

TIMKEN® "Double-Zero" bearing has run-out reduced by half!

HERE'S an opportunity for new and greater precision in machine tools, scientific instruments, and other machinery where extreme accuracy is essential. It's the new Timken "Double-Zero" bearing—*twice as accurate* as the most accurate Timken bearing previously made!

Maximum run-out tolerance, the standard of bearing accuracy, is only 75 millionths of an inch in the "Double-Zero" bearing, compared to 150 millionths in the Timken "Zero" bearing—until now the most accurate Timken bearing on the market.

NEW MACHINES AND INSTRUMENTS

Producing bearings accurate to a few millionths of an inch calls for machines and measuring instruments of equal accuracy. To determine surface accuracy, Timken developed the Profilograph, which measures microscopic irregularities to within one millionth of an inch. To gauge run-out, the Timken research organization invented the concentrometer, which measures concentricity to within 5 millionths of an inch.

And Timken engineers designed and built many special types of machine tools to provide the required manufacturing accuracy. Machines and instruments like these, plus painstaking manufacturing methods based on years of bearing experience, made possible the extremely close tolerances in the new "Double-Zero" bearing.

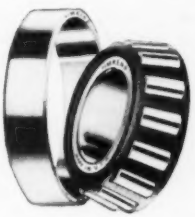
As an extra step in manufacture, after assembly, a natural and true geometric contact is generated between all rotating parts of the "Double-Zero" bearings. This results in a "Generated Unit Assembly". It assures positive roll alignment, long lasting precision, permanent adjustment and smoother operation.

The new "Double-Zero" bearing is the latest example of Timken leadership in serving the bearing needs of all industry. Whenever you buy bearings, it pays to look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

A PRECISION TIMKEN BEARING FOR EVERY REQUIREMENT

CLASS	"00" (Double-Zero)	"0" (Zero)	"3" (Three)
RUN-OUT	.000075"	.000150"	.000300"
TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
SIZE RANGE	Up to 10" O.D.	Up to 12" O.D.	Up to 12" O.D.

TIMKEN
TRADE-MARK REG. U.S. PAT. OFF.
TAPERED ROLLER BEARINGS



NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST ◫ LOADS OR ANY COMBINATION ✳